# SCIENCE

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MSS. intended for publication and books, etc., intended for review should be sent to Professor J. McKeen Cattell, Garrison-on-Hudson, N. Y.

## *MULTIPLICITY OF CROPS AS A MEANS OF INCREASING THE FUTURE FOOD SUPPLY*[1]

ECONOMISTS prophesy a deficiency in the world's food supply. The cost of living everywhere portends accuracy in their divination. The fast and furious struggle between nations and individuals for land upon which to grow food augurs lean years to come. Census enumerations of population presage sooner or later a dearth of ammunition among the multiplying peoples of the earth to carry on the battle of life. Of all this you need to be reminded rather than informed.

So many men have stated and attempted to solve the problem of the future food supply that it would seem that the subject has been wholly talked out from the facts at hand. Indeed, there has been so much said and written about hard times at hand and famine ahead that I doubt if you are pleased to have your premonitions reawakened by further forebodings and to be forced, through the prestige of the president's chair, to give attention to a subject which has been so much discussed. Thrashing over old straw in the presidential chair is, I quite agree with you, a most abominable practise and I have done my best to bring a few sheaves of grain to the thrashing I am now beginning.

Agricultural economists discuss three rather general means of securing a food supply for those who live later when the earth teems with human beings. These are: conservation of resources; greater acreages under cultivation; and increased

[1] Presidential address, Society for Horticultural Science, Washington, D. C., 1913.

yields from improved plants and through better tillage. It is difficult to anticipate the problems that will confront us when people swarm on the land, as now in India or China, but I venture the prediction that if in that day "the evil arrows of famine" are sent upon us, a fourth means of supplying food will be found quite as important as the three named.

We shall find, long before famine overtakes us, that the natural capacity of soils and climates to produce a diversity of crops is one of the greatest resources for an increased food supply. As yet, multiplicity of crops as a means of augmenting the supply of food has received little attention and I want to bring you to a better realization of its possibilities in the half hour at my disposal, attempting to show, in particular, how greatly the necessities and luxuries of life can be increased by the domestication of wild esculents; by better distribution of little-known food plants; and by the amelioration of crops we now grow through breeding them with wild or little-known relatives.

Few, even among those who have given special attention to agricultural crops, have a proper conception of the number that might be grown. De Candolle, one of the few men of science who have made a systematic study of domesticated plants, and whose "Origin of Cultivated Plants" has long been sanctioned by science as authoritative, is much to blame for the current misconception as to the number of plants under cultivation. By conveying the idea that his book covers the whole field, De Candolle prepared the ground for a fine crop of misunderstandings.

Humboldt had stated in 1807 that

> The origin, the first home of the plants most useful to man, and which have accompanied him from the remotest epochs, is a secret as impenetrable as the dwelling of all our domesticated animals.

De Candolle set out to disprove Humboldt. He assorted cultivated plants in 247 species and ascertained very accurately the histories of 244 out of the total number. De Candolle's thoroughness, patience, judgment, affluence of knowledge, clear logic and felicity of expression, make his book so trustworthy and valuable in most particulars, that we have accepted it as the final word in all particulars, overlooking his faulty enumeration and forgetting that most of his material was gathered more than a half century ago.

My first task is to establish the fact that the number of plants now cultivated for food the world over is not appreciated in either science or practise. Neither are botanists nor agriculturists seemingly well aware of the number of edible plants not domesticated which are in times of stress used in various parts of the world for food, many of which can well be grown for food. Your attention must be called to the number of these.

Inspiration for this discussion of the undeveloped food resources of the plant-kingdom came to the speaker from the use of notes left at the New York Agricultural Experiment Station by the first director of the station, the late Dr. E. Lewis Sturtevant, who gave most of his life to the study of economic botany. His pen contributions on cultivated plants in agricultural and botanical magazines cover thirty years and number many titles. In addition, the unpublished material just mentioned, under the heading "Edible Plants of the World" takes up over 1,600 typewritten pages. During his life, Dr. Sturtevant was in the full tide of American science, but I am sure could he have lived to publish the great treatise which he had planned on edible plants, and upon which he worked for twenty years, we should give him much higher rank with giants of science,

and that his book would now be the *magnum opus* of economic botany.

De Candolle, as we have seen, includes but 247 cultivated species in his work. This is approximately the number generally thought to minister to the alimentary wants of man. Sturtevant, in his notes on edible plants, enumerates 1,113 domesticated species now cultivated, and a total of 4,447 species, some part or parts of which are edible. Following De Candolle, Sturtevant made use of botany, archeology, paleontology, history and philology in obtaining his data. He searched the literature of the world from the earliest records in Egyptian, Chinese and Phœnician until the time of his death to make a complete record of the edible plants of the world. Sturtevant's were the species, too, of a generation ago, many of which have since been divided twice, thrice or oftener by later botanists. It is said that no food plant of established field culture has ever gone out of cultivation, an approximate truth, at least, from which we may presume that the number of cultivated plants is not smaller than the numbers given from our author's notes.

In leaving this phase of my subject, I can not but say that, despite the fulness of Sturtevant's notes, the feeling comes in reading them, as it does in reading De Candolle, Darwin or whoever has written on the domestication of plants, that what has so far been found out is so little in comparison to what we ought to know regarding the modification of cultivated plants by man, that our present knowledge but makes more apparent the dire poverty of our information.

Passing now to a more direct discussion of the subject in hand, I have to say that I have chosen to discuss three general means of developing the latent possibilities in the plant-kingdom for agriculture. It may help to hold your attention if I discuss these in order of their importance—the most important last. They are: First, the domestication of the native plants of any region. Second, better distribution of plants now cultivated. Third, the utilization of hybridization to bring into being new types of plants better suited to cultivation and to the uses of man.

In the matter of domesticating plants let us glance hastily at what has and what can be done in our own country. In De Candolle's treatise we make but a poor showing, indeed. Out of his 247 cultivated species but 45 are accredited to the New World and but three of these—the pumpkin, Jerusalem artichoke and persimmon—come from North America. To these three Sturtevant adds about thirty. The poor showing made by our continent in furnishing food plants, it must be made plain, is not due to original inferiority. The number would be vastly greater, as Asa Gray long ago pointed out, had civilization begun in this rather than in the Old World. It is probable, indeed, that the numbers would be approximately equal if civilization had begun as early in the Western as in the Eastern Hemisphere.

What are some of these plants that Gray and other botanists have so often told us might have been and may yet profitably be domesticated? The list is far too long to catalogue, but you will permit me time for a few examples, choosing those that are still worth domesticating for some special purpose or environment. Fruits give us most examples.

Wild fruits abound in North America. The continent is a natural orchard. More than 200 species of tree, bush, vine and small fruits were commonly used by the aborigines for food, not counting nuts, those occasionally used, and numerous rarities. In its plums, grapes, raspberries,

blackberries, dewberries, cranberries and gooseberries North America has already given the world a great variety of new fruits. There are now under cultivation 11 American species of plums, of which there are 433 pure-bred and 155 hybrid varieties; 15 species of American grapes with 404 pure and 790 hybrid varieties; 4 species of raspberries with 280 varieties; 6 species of blackberries with 86 varieties; 5 species of dewberries with 23 varieties; 2 species of cranberries with 60 varieties and 2 gooseberries with 35 varieties. Here are 45 species of American fruits with 2,226 varieties, domesticated within approximately a half century. De Candolle named none of them. The final note of exultation at this really magnificent achievement of American horticulture would typically be uttered in a boast as to the number of millions of dollars these fruits bring fruit-growers each year, but science is not sordid and the calculation, I am sure, would not interest you.

What more can be done? The possibilities of the fruits named have by no means been exhausted. The fruit of the wild plum, *Prunus maritima,* an inhabitant of sea-beaches and dunes from New Brunswick to the Carolinas, is a common article of trade in the region in which it grows, but notwithstanding the fact that it readily breaks into innumerable forms and is a most promising subject under hybridization, practically nothing has yet been done toward domesticating it. Few plants grow under such varied conditions as our wild grapes. Not all have been brought under subjugation, though nearly all have horticultural possibilities. It is certain that some grape can be grown in every agricultural region of the United States. The blueberry and huckleberry, finest of fruits, and now the most valuable American wild fruits, the crops bringing several millions of dollars annually, are not yet domesticated. Coville has demonstrated that the blueberry can be cultivated. Some time we should have numerous varieties of the several blueberries and huckleberries to enrich pine plains, mountain tracts, swamps and waste lands that otherwise are all but worthless. A score or more native species of gooseberries and currants can be domesticated and should some time extend the culture of these fruits from the Gulf of Mexico to the Arctic Circle. There are many forms of juneberries widely distributed in the United States and Canada, from which several varieties are now cultivated. The elderberry is represented by a dozen or more cultivated varieties, one of which, brought to my attention the past season, produced a half hundred enormous clusters, a single cluster being made up of 2,208 berries, each a third of an inch in diameter.

These are but a few of the fruits—others which can only be named are: the anonas and their kin from Florida; the native crab-apples and thorn-apples; the wineberry, the buffalo-berry and several wild cherries; the cloud-berry prized in Labrador; the crow-berry of cold and Arctic America; the high-bush cranberry; native mulberries; opuntias and other cacti for the deserts; the paw-paw, the persimmon, and the well-known and much-used salal and salmon berries of the west and north.

The pecan, the chestnut and the hickory-nut are the only native nuts domesticated, but some time forest and waste places can be planted not only to the nuts named, but to improved varieties of acorns, beech-nuts, butternuts, filberts, hazels, chinquapins and nut-pines, to utilize waste lands, to diversify diet and to furnish articles of food that can be shipped long distances and be kept from year to year. The fad of to-day which substitutes nuts for meat may become a necessity to-morrow. Meanwhile

it is interesting to note that the pecan has become within a few decades so important a crop that optimistic growers predict in another half century that pecan groves will be second only to the cotton fields in the south. A recent bulletin from the United States Department of Agriculture describes 67 varieties, of which more than a million and a half trees have been planted.

It is doubtful whether we are to change general agriculture much by the domestication at this late date of new native grains, though many may well be introduced from other regions and wonderful improvement through plant-breeding is, as all know, now taking place. Raw material exists in America for domestication, but it is not probable that we shall ever use it extensively.

There are, however, a number of native vegetables worth cultivating. The native beans and teparies in the semi-arid and sub-tropical southwest to which Freeman, of the Arizona station, has called attention, grown perhaps for thousands of years by the aborigines, seem likely to prove timely crops for the dry-farmers of the southwest. Professor Freeman has isolated 70 distinct types of these beans and teparies, suggesting that many horticultural sorts may be developed from his foundation stock. The ground-nut, *Apios tuberosa,* furnished food for the French at Port Royal in 1613 and the Pilgrims at Plymouth in 1620, and as a crop for forests might again be used. There are a score or more species of *Physalis,* or ground cherries, native to North America, several of which are promising vegetables and have been more or less used by pioneers. *Solanum nigrum,* the nightshade, a cosmopolite of America and Europe, recently much advertised under several misleading names, and its congener, *Solanum triflorum,* both really wild tomatoes, are worthy of cultivation and in fact are readily yielding to improvement. *Amaranthus retroflexus,* one of the common pigweeds of gardens, according to Watson, is cultivated for its seeds by the Arizona Indians. In China and Japan the corms or tubers of a species of *Sagittaria* are commonly sold for food. There are several American species, one of which at least was used wherever found by the Indians, and under the name arrowhead, swan potato and swamp potato has given welcome sustenance to pioneers. Our native lotus, a species of *Nelumbo,* was much prized by the aborigines, seeds, roots and stalks being eaten. *Sagittaria* and *Nelumbo* furnish starting points for valuable food plants for countless numbers of acres of water-covered marshes when the need to utilize these now waste places becomes pressing.

The temptation is strong to continue this discussion of the domestication of native plants, but time demands that I pass to a consideration of the second potential of an increased diet, that of better distribution of the world's food-producing plants.

Beginning with the discovery of the New World, botanical and agricultural explorations have been carried on with zeal, and food plants have been interchanged freely between newly discovered lands and older civilizations. Yet in these centuries the food-plant floras of races have been changed but little. Quite too often a crop is found to be the monopoly of a race or nation irrespective of soil and climate, factors which ought to impose a cultivated flora. It would seem that agriculturists would quickly adopt food plants grown elsewhere of which the advantage is evident, and be thereby diverted from the cultivation of poorer crops in their own country. Yet the introduction of foreign plants is usually arrested, if not actually opposed, by the timidity of agriculture, and it has been most difficult to introduce new crops into

old regions. This conservation on the part of those who grow the food plants of the country is due to a universal dislike in the animal kingdom, most strongly developed in the human family, to eating unfamiliar foods. But travel is making all people less and less fastidious as to foods, as the numerous new foreign dishes in daily use in our own homes give evidence. Only savages and those who must struggle for sufficient food to sustain life live on one or a few foods.

Let us hastily run over a few foreign plants that may well receive more attention in America, naming fruits first as of most interest to this audience. Japanese plums and persimmons came to America in the medieval days of horticultural progress, and interest in them seems to have ceased. We need new importations of the many types not yet in the country. The fig is an ancient immigrant, but I am told that many desirable relatives were left behind. Date culture is now a most promising infant industry in the southwest. The Chinese jujube promises to be one of the most valuable of the many plants recently introduced into this country. The jujube is a hardy tree which has been cultivated in China for more than 4,000 years, being one of the five principal fruits of the new republic. There are hundreds of varieties differing in flavor and sizes, some growing less than an inch in length and others equaling the size of a hen's egg. One variety is seedless. Some kinds are eaten fresh, some are stewed.

Among the newest of the new on probation, but all clamoring for recognition, are the avocada from tropical America; the feijoa from Brazil; a dozen or more annonaceous fruits from the tropics, of which the cherimoya seems now to be most prominent; an edible Osage orange from Central China; the roselle, an annual from the Old World tropics, valuable for its fruit, stalks and seed. Several species of *Berberis* supply a refreshing fruit in northern Asia and might add variety to the rather spare fruit diet of the colder parts of this continent. Beside these are innumerable new citrus fruits, the number of species and varieties of which seem to be legion—the speaker is neither able to enumerate them nor to tell where they begin or where they leave off. Swingle's splendid work with this genus is one of the most notable contributions to horticulture in recent years.

The mango has long been grown in Florida, but interest in mangos has recently been renewed through the introduction of choice Indian varieties. Poponoe describes 312 varieties of mangos grown in various parts of the world, of which as yet I judge there are but few in America, though they are not difficult to grow in Florida, California or in our insular possessions. A quotation from Fairchild suggests the possible future of the mango in America. He says:

> The mango is one of the really great fruits of the world. . . . There are probably more varieties of mangos than there are of peaches. I have heard of one collection of five hundred different sorts in India. There are exquisitely flavored varieties no larger than a plum, and there are delicious sorts, the fruits of which are six pounds in weight. . . . These fine varieties, practically as free from fiber as a freestone peach, can be eaten with a spoon as easily as a canteloupe. Trainloads of these are shipped from the mango-growing centers of India and distributed in the densely peopled cities of that great semi-tropical empire.

No one can read Bayard Taylor's fervent praise of the durian and the mangosteen and not desire to grow these fruits in America. This is his panegyric on the durian.

> Of all fruits, at first the most intolerable; but said, by those who have smothered their preju-

dices, to be of all fruits, at last, the most indispensable. When it is brought to you at first, you clamor till it is removed; if there are durians in the next room to you, you can not sleep. Chloride of lime and disinfectants seem to be its necessary remedy. To eat it seems to be a sacrifice of self-respect; but, endure it for a while, with closed nostrils, taste it once or twice, and you will cry for durians thenceforth, even—I blush to write it—even before the glorious mangosteen.

Listen to his laudation of the "glorious mangosteen."

Beautiful to sight, smell and taste, it hangs among its glossy leaves the prince of fruits. Cut through the shaded green and purple of the rind, and lift the upper half as if it were the cover of a dish, and the pulp of half-transparent, creamy whiteness stands in segments like an orange, but rimmed with darkest crimson where the rind was cut. It looks too beautiful to eat; but how the rarest, sweetest essence of the tropics seems to dwell in it as it melts to your delightful taste.

One need not titillate the palate to enjoy such fruit. Can they be so delectable? Surely we can find a place for them somewhere in America.

Let us turn to a few examples of promising vegetable and farm crops of foreign countries not yet cultivated in the United States. Only those which give most emphasis to the present paper can be mentioned.

All know that rice furnishes the chief food of China, but few are aware that sorghum is as important a crop in Asia as rice and that it is the chief food of a large part of Africa. In China not only are the stalks of sorghum used, but bread is made from the seeds. In parts of India, sorghum is the staff of life. The Zulu Kaffirs live on the stalks, which are chewed and sucked, and Livingstone says "the people grow fat thereon." The several species of yams constitute one of the cheapest and most widely distributed food plants in the world, yet the yam is little grown in America. Several genera of Aroideæ, as *Caladium*, *Alocasia*, *Colocasia* and *Arum*, each with innumerable varieties, furnish taro, arrowroot, ape and other more or less familiar food to the South Sea islanders. In a bulletin from the United States Department of Agriculture, under the title, "Promising Root Crops for the South," these Aroids, called under their native names of yautias, taros and dasheens, are recommended as most valuable wet-land root crops for the South Atlantic and Gulf States. Of the place of the cocoanut in the world's economy I need not speak. Varieties of *Maranta* were grown in Mississippi and Georgia in 1849, but disappeared. From one of the several species of this genus comes the arrowroot of commerce. Arrowroot is a favorite food of the Feejees and their neighbors, as well as of the inhabitants of Cape Colony, Natal and Queensland. May not arrowroot some time be produced profitably in America? The banana has been on our tables less than a generation, yet it is now one of the commonest foods. There are several species and many varieties yet to be introduced into the tropics of America. The leaves and buds of several agaves furnish an abundant and a very palatable food to our southern neighbors. From plants of the large genus *Manihot* of equatorial regions, tapioca is made under conditions which could be greatly improved. As cassava, one of these manihots is already important in the United States and may some time compete with corn and wheat in the food supply of the country.

To quench the thirst of the teeming millions in time to come there may be a multiplicity of beverages as well as of foods to mitigate hunger. In Arabia several millions of people drink khat, while in southern South America as many more millions allay their thirst with maté. Maté, according to Fairchild, can be produced

at but a fraction of the cost of tea and supplies the same alkaloid in a more easily soluble form. Both contain thein, the active principle in "the cups that cheer but not inebriate." Sturtevant names twelve plants the leaves of which are used in different parts of the world to adulterate or in place of tea. We have but just acquired the use of cocoa and chocolate from the natives of our American tropics and of cocacola from the negroes of Africa, and it is not unlikely that we shall find other similar stimulants. For drinkers of more ardent beverages, if King Alcohol continues to reign, there is an abundance, the diversity and cheapness of which probably will ever as now be regulated by taste and taxes.

Time prevents my naming other valuable foreign plants that deserve to be tried in our agriculture. It is fortunate for American farming that men from the United States Department of Agriculture are now searching everywhere for new material. Saul went in search of asses and came back with a crown. So these men sent to foreign countries for material, possibly commonplace enough, are bringing back treasures the value of which in many cases will be incalculable. Introduction of seeds and plants for the nation is work to which the institutions represented here should lend aid in every way possible.

The last of the three means of developing plants for food, and as I believe the most important, is by using either foreign species or wild native species to hybridize with established crop-plants. It needs but a brief statement of what has been accomplished in increasing hardiness, productiveness, disease resistance, adaptability to soil and other essentials of standard crop-plants, to show that through hybridization of related species we have probably the best means of augmenting our diet. Let us glance at a few recent accomplishments of hybridization, noting chiefly results with horticultural plants.

Downing in 1872 described 286 varieties of 4 species of plums. In the 40 years that have elapsed the number has increased to 1,937 varieties representing 16 species. Now the significant thing is that whereas Downing's plums were pure-bred species, 155 of the present cultivated plum flora are hybrids between species. Downing could recommend plums for only a few favored regions. Some kind of plum can be grown now in every agricultural region in North America. Even more remarkable is the part hybrids have played in the evolution of American grapes. At the beginning of the nineteenth century, the grape could not be called a cultivated crop on this continent. Now there are 16 species and 1,194 varieties, the most significant fact being that 790 or three fourths of the total number are hybrids. The grape through hybridization has become one of the commonest cultivated plants. The genus *Rubus* promises to attract and distract horticulturists next. As nearly as I can make out there are about 60 species of *Rubus* in North America. In the two completed parts of Focke's "Species Ruborum," 273 species are described. Raspberries, blackberries, dewberries and their like hybridize freely and we already have in the loganberry, the purple-cane raspberry, the wineberry and in the blackberry-dewberry crosses valuable fruits. If any considerable number of Focke's several hundred species can be similarly mixed and amalgamated, the genus *Rubus* will be one of the most valuable groups of fruits.

The speaker is studying cultivated cherries. When the work began a few years ago about a score of species were in sight. Koehne, a recent botanical monographer of the sub-genus *Cerasus*, to which

our edible cherries belong, describes 119 species, many of them but recently collected by Wilson in Asia. There are enough hybrids between species to indicate that cultivated cherries will some time be as diversified as plums and with quite as much advantage to the fruit.

Webber's and Swingle's work in breeding hardy citrus fruits; blight-resisting pears as a result of crossing *Pyrus communis* and *Pyrus sinensis;* Burbank's spectacular hybrid creations; the diversity of types of tomatoes, potatoes, egg-plant, peppers, beans, cucurbits and other vegetables, not to mention roses, chrysanthemums, orchids and innumerable flowers, suggest the possibilities of hybridization. We have not done what lies within our reach in crossing cereals—corn, wheat, oats, rye, buckwheat, the last especially, remain yet to be touched by the magic wand of hybridization. Hybrid walnuts, chestnuts, hickories and oaks, promise a wonderful improvement in nuts.

Truth is we do not know how much nor what material we have to work with in many of the group of plants I have named, lending color to the saying that the plants with which man has most to do and which render him greatest service are those which the botanists know least. This brings me to the last division of my subject.

Nothing is more certain than that we are at the beginning of a most fertile period in the introduction of new and the improvement of old food-plants. Yet agricultural institutions are most illy prepared to take part in the movement. "Art is long and time is fleeting," can be said of no human effort more truly than of the improvement of plants, and haste should be made for better preparation. Looking over the material that is usable in agricultural institutions, it seems that we are sadly lacking in the wherewithal upon which to begin. It is indispensable for effective work that we have an abundance of material and that we know well the plants with which we are to work.

How may the material be had? We are fortunate in the United States in having the Office of Foreign Seed and Plant Introduction of the United States Department of Agriculture for the importation of foreign plants. This office has effective machinery for the work. It maintains agricultural explorers in foreign countries. It is in direct contact with the agricultural institutions of other countries as well as with plant-collectors, explorers, consuls, officers of other countries and missionaries. Through these agents it can reach the uttermost parts of the world. Moreover, it has trained men to identify, to inventory, to propagate and to distribute foreign plants. This office can better meet quarantine regulations than can private experimenters or state institutions. All interested in foreign plants ought to work in cooperation with the Office of Foreign Seed and Plant Introduction of the Department of Agriculture.

To be used advantageously material must be near at hand. This means that there must be botanic gardens. There should be in every distinct agricultural region of the country a garden where may be found the food plants of the world suitable for the region. It is strange that in the lavish expenditure of state and federal money in the agricultural institutions of the land, that so little has been done to establish and maintain comprehensive plantations of economic plants. Now that the amelioration of plants is a part of the work of agricultural colleges and stations it would seem that the establishment of such gardens is imperative. True, there are botanic gardens, but the museum idea is dominant in most of them—they contain the curiosities of the vegetable kingdom, or they show the

ornamental and beautiful, or they are used for purposes of instruction. We need agricultural gardens in which agricultural plants are dominant rather than recessive.

There is another difficulty quite as detrimental to progress as inability to obtain material. It is the lack of trustworthy information in regard to economic plants. Quite as necessary as agricultural gardens is an agricultural botany. In this botany must be set forth, besides descriptions of species, the habitat, the migrations, the geographical relations to other plants, the changes that have occurred, how the plant is affected by man-given environment, and all similar data. Physiological facts regarding germination, leafing, flowering and fruiting must be given. The production of such a book is a consummation devoutly to be wished. At present the information needed is best supplied by Bailey's splendid cyclopedias, but there is need of more historical and biological knowledge in agricultural botany.

I had thought to say a few words about the men who are to do this work. Material and books do not create. The man has not been lost sight of, but I should have to set forth his temper and training too hurriedly even if I could properly conceive them. But from the beginning to the end of this new shaping of food crops, the individual man trained for the work will be dominant. The work to be done, however, is so vast that we can not make an appreciable showing unless the task be divided among a great number of workers. Those who will do most are such as can concentrate on particular problems the sifted experience and knowledge of the world. Many may sow, but only the strong can garner.

There should be unity of action to avoid waste. What more pathetic spectacle than that of isolated men in our agricultural institutions attacking one and the same problem in which they duplicate errors and waste their efforts in what too often proves with all to be petty circle-squaring. Much of this appalling waste can be avoided by a proper spirit of cooperation. By all means let us cooperate in the amelioration of plants.

In conclusion, I must end as I began by calling attention to the great probability of a near-at-hand deficiency of food. I must again urge the importance of making use of every means of increasing the supply. I have tried to call attention to the desirability of growing a greater number of food-plants as one of the means. Not to attempt to develop and utilize to its highest efficiency the vast wealth of material in the plant-kingdom for the world's food is improvidence and is a reckless ignoring on your part and mine of splendid opportunities to serve our fellow men. It is my hope that the horticultural departments of the agricultural colleges and experiment stations of North America, represented by members of this society, may become active agents in increasing the number of food crops and thereby the world's food supply.

U. P. HEDRICK

## *HEADSHIP AND ORGANIZATION OF CLINICAL DEPARTMENTS OF FIRST-CLASS MEDICAL SCHOOLS*[1]

Two recent official manifestations with reference to the problem of full-time clinical positions deserve to be put at the head of our

[1] This manuscript has been prepared for the president and trustees of a university in answer to the following questions:

"First: What should be the relation of the hospital to a first-class medical school? The question is asked . . . to bring out the ideal relationship. For instance, to what extent should the school own, control, or manage its teaching hospital in its medical and in its administrative functions.

discussion, because they come from the most important educational bodies in medical matters in this country and because they throw light upon the acuteness and the present status of our problem. (1) The Johns Hopkins University has recently appointed full-time professors of medicine, surgery and pediatrics. There under the term "full-time professorship" two obligations are included. In the first place the head of a clinical department must give as much of his time to his department as other full-time university professors give of their time, for instance, as the professors of physiology and pathology give to their departments. In the second place, the head of a clinical department can not give any of his spare time to any clinical venture which may bring him material gain. It is interesting and instructive to find that this plan was advocated twelve years ago by Dr. L. F. Barker, while he was professor of anatomy at the University of Chicago. Here is what he said then:[2]

> They (the full-time professors of clinical subjects) should be well paid by the universities. They should not engage in private practise even if the university has to pay them double the ordinary salary now paid a university professor to retain them wholly in university work. If any patients at all outside the hospital were seen in consultation, and there is some force in the argument that the well-to-do public should, at least in some rare and difficult cases, be permitted to profit by the opinion and advice of the university professor, the fees received from them may be contributed to the budgets of the hospital themselves, in order to remove all temptation from the staff.

2. The second manifestation is contained in the official Report of the Council of Medical Education made at the last meeting of the American Medical Association.[3] This report speaks of the Johns Hopkins plan, according to which the full-time professors "may do private practise, but that fees from that practise are to be turned into the university treasury and not into their own pockets," as *grotesque*. The report lays stress upon the fact that this plan was proposed by non-medical men (that is, the General Education Board) who "do not have the medical point of view and do not understand the complex functions demanded of the clinical teacher." It may be said here in parenthesis that the term "non-medical men" is in this case not entirely correct, as the plan was surely suggested, advocated and accepted by important members of the Medical School, for instance the professors of pathology, physiology, anatomy, etc. However, this designation remains true to the extent that some of the medical men who advocated these radical changes in the department of medicine have practical knowledge only in the sciences closely associated with medicine, but not in the domains of clinical medicine itself. The report, however, acknowledges the fact that at present the placing of the clinical departments in the medical school on a satisfactory basis is one of the most pressing needs.

> With this in view the council of Medical Education has appointed a strong committee of ten clinicians, who have had great experience in teaching and who are regarded as authorities in their special department and in medical education, to study this subject and to report to the next conference on medical education. . . . The medical school very properly demands that their clinical teachers be men who are recognized as authorities in their special fields both by the profession and by the community . . . whatever plan is adopted must make it possible for the clinical teachers to remain the great authorities in their special fields both in the eyes of the profession and in the eyes of the public.

The report of the council does not state directly that the present status of teaching in the clinical departments in the medical schools of this country is very unsatisfactory. It admits it, however, tentatively, when it states that the placing of this teaching on a very satisfactory basis is one of the most pressing needs. We have seen that the Johns

''Second: How important do you believe full-time positions in the clinical subjects are for a satisfactory connection between the school and hospital?''

[2] *Amer. Medicine*, 1902, Vol. 4, p. 146.

[3] *The Journal of the American Medical Association*, LXIII., 1914, 86.

Hopkins University already began to experiment with a cure for this unsatisfactory condition. The Council of the Medical Education finds this cure grotesque and defers its own therapeutic plans until the committee of ten clinicians has rendered its report on this problem. Now, we never ought to offer any treatment before we know exactly the nature of the ailment. What ails the instruction and instructors in clinical subjects in the medical schools in this country? I do not find that this phase of our problem, perhaps its most essential part, has been anywhere analyzed. I shall therefore attempt to do it here.

The report of the Council on Medical Education lays great stress upon the requirements that the clinical teachers must be "great authorities in their special fields both in the eyes of the profession and in the eyes of the public." If that would be really the main criterion of fitness, I would then say that professors of medicine of to-day fulfill, at least in most instances, their mission: they are great authorities in the eyes of the public and the profession; their offices are full and they are consulted by physicians and the sick from near and far. But are these authorities well-fitted to be heads of clinical departments? According to my way of thinking, I would say that in most instances they are unfit for these positions. Now let me give my reasons for this statement, which may sound a little too severe.

I wish to introduce my argument by the following two propositions, the correctness of which ought to be apparent to every one. (1) The proper preparation of practitioners of medicine is a very serious task; it is of great importance to the public as well as to the student of medicine himself, and ought, therefore, to be carried out as a *primary occupation* and in an earnest and conscientious manner. (2) No matter whether we take a progressive or a conservative stand in medicine, one and all must agree that the *student of medicine of to-day must be taught the medical knowledge as it is known to-day.* For this purpose let us look at the activities of any head of a clinical department, let us say, of internal medicine, who is, as the council demands, "a recognized authority in his field in the eyes of the profession and of the public"; let us see whether these activities comply with the above-mentioned self-evident requirements. Let us first scrutinize the history of one day of one of our noted professors of medicine. He has consultation hours every morning until noon; the waiting room is crowded (he is the "best diagnostician" in his town) and sometimes he has to remain in his office an hour or two longer. As a rule he has to accept a few bedside consultations with practitioners, which again takes up many hours of his time in the afternoon. He may even have to go out of town for consultations. At any rate, including the time given to his meals, etc., about ten hours of his day are easily accounted for by this activity. Then on account of his high social standing in the community, etc., functions have to be attended, for which his wife makes the engagements; dinners have to be attended and to be given; meetings of advisory boards and of all sorts of committees have to be attended. Then there are letters to be written or dictated, bills and other business matters to be looked after. No doubt that by these diverse obligations at least about three more hours of the day are consumed. We have thus far accounted for about thirteen hours every day of the professor's time. Now how much of his time is then left for teaching medicine to students and attending to the sick at the hospital? If I say three hours, I am sure it is exaggerated in most cases. But whether two or three hours, they are hours left over from a very busy active occupation, and the teaching is then done in most cases by a worn-out man bodily and mentally. It will be generally admitted that for nearly all teachers of clinical subjects private practise, with its commercial end, is the chief aim and occupation, while the teaching part is at best only a minor subject, and in not a few instances only an ornament and unmistakably a very desirable advertisement. I remember how years ago a noted surgeon, who was the professor of surgery at one of the best-known

medical schools, said to me: "They pay me a thousand dollars a year. The fools! I would pay them $5,000 for the professorship; it's worth more than $25,000 a year to me." What a deplorable condition! The teaching of the pure medical branches which, for the physician in the making, is the most important part of his medical education, should be carried on by worn-out men for whom it is invariably only a secondary occupation and often not much more than an ornament or an advertisement!

Now let us come to the second proposition. We have seen that the professor of medicine, who is considered an authority by the profession and the public, is so busy that very little time is left to him to carry on properly his duties as a teacher. Is there any time left him to study properly the advances which are continually made in medicine? Let us study the medical career of the best medical consultant and professor. He graduated in medicine at the head of his class, he served as an interne at a good hospital, he went abroad, where he learned the then newest things in medicine. After his return he soon became assistant to a leading consultant and a professor. For several years he made for his chief laboratory examinations with the older and newer methods of diagnosis, saw some of the chief's private patients, and was soon appointed adjunct at the hospital and instructor in the department of medicine of which his chief was the head. He saw some of the autopsies and compared them with the diagnoses; found time to read some of the newer medical literature, made himself several contributions to it; assisted his chief in preparing and giving the lectures and helped him in preparing a paper or two which had to be flavored with some of the newer things in medicine. Gradually he picked up a private practise of his own, which suddenly commenced to grow rapidly. He had to leave his chief, consultations began to come in, and in a short time he advanced to the position of attending physician in several hospitals, and perhaps also to the position of a clinical professor in his school. His reputation and his private practise grew, and with it grew his extensive personal experience; he was becoming indeed an excellent physician. But in exact proportion to this growth his spare time grew less and less, and with it grew fainter and fainter the first-hand acquisition of knowledge of the advances of medicine, which are going on in rapid strides all over the world. There was no longer any idea of doing some original work or of a patient study of communications on entirely new subjects which continually spring up in rapid succession. There was no real reading any more; perusing of some articles, glancing at abstracts, picking up one thing or another at meetings and discussions, had to take the place of study. Our authority is not an old fogy who does not believe in the truth of things which he does not know. On the contrary, he is a progressive man and knows how to get at the new things. With a growing income and with the cheapness of scientific labor, he learned early to surround himself with several young assistants, specializing in various directions. The morphology and the chemistry of the urine; the various morphological blood pictures, and the chemistry of the blood; the bacteriology of diverse diseases and the various immunity reactions; metabolic studies, phlebograms and cardio-electrograms, etc., our authority gets a report on all of them and is told of their possible significance by his various young assistants. Of course, his knowledge of these things as he picks them up is extremely superficial; they can be thoroughly grasped only by hard study. But our authority has to use, and uses, this superficial knowledge of new things in consultations at the bedside, in the lecture room and in papers and discussions at medical meetings.

To state it briefly: the store of more solid knowledge of the best clinical teacher, as we know him to-day, consists of that which he had acquired during his undergraduate and post-graduate studies and of the accumulated personal knowledge gained by long empirical observations at the bedside. Of the marvelous advances which are continually made in all

branches of medicine all over the world our clinical teacher has at best only a very superficial knowledge and ought not to be the man to teach them to the physician of the future.

The foregoing analysis shows, I believe, conclusively, (1) that the teaching of medicine to the future physicians is for nearly all the heads of clinical departments only a secondary occupation and in some instances it is not more than an ornament or a legitimate business advertisement; and (2) that most of the present heads of departments do not possess sufficient familiarity with the modern medicine to be the instructors of present-day medicine to the coming physician.

The source of this anomalous situation is to be found in the fact that heads of departments of medicine are chosen from the class of physicians who are primarily busy practitioners and consultants. They may be noted men in their line and perhaps are indeed all that the Council on Medical Education is laying stress upon, namely, "great authorities in their special fields both in the eyes of the profession and in the eyes of the public." But on account of that very virtue they are in such demand in their private practise that for years they could find no time to follow up seriously the rapid advances in medicine. For the same reason they are compelled to treat their vocation as educators in the science and practise of medicine only as a secondary occupation—which alone is bound to bring unsatisfactory results, even if our professors were well fitted to teach the medicine of to-day.

There is no doubt, then, that the present mode of instruction of clinical subjects is very unsatisfactory. Let us now examine the methods by means of which the anomalous situation could be mended best. I wish to present at first my own suggestion very briefly. I have pointed out before that the source of the evil is to be found in the fact that at present the heads of the departments are chosen from a class of very busy practitioners, for whom teaching is invariably only a secondary occupation. That fact points to the following plan as the most efficient remedy for our evil. Heads of departments should be chosen from a class of physicians who from the time of their medical graduation never ceased to be close students of their science, and for whom the study of and instruction in a chosen clinical subject constitutes their primary occupation. To the question, where can we get this class of physicians? my answer is: create it, or, more correctly expressed, accelerate its development, since a fairly good beginning has been made in the last few years. I shall return later to this suggestion and discuss it in detail.

In considering plans for correction, we ought to bear in mind that we are confronted not with one evil alone, but with two, namely, that (1) the present instructor in clinical subjects can not and does not give his best time to his calling as a teacher, and that (2) he has been for many years out of close touch with the advances in the medical sciences and is therefore unfit to teach them efficiently. Looking at our problem from this point of view, it is evident that the creation of "full-time" clinical professors will not cure the second evil. Suppose a large number of noted consultants, who are at present the professors of medicine in the various schools, resolve henceforth to make teaching their primary or even their exclusive occupation—will this resolution convert them at once into desirable educators, fit to teach efficiently modern medicine? There may be many things which they will have to learn from the beginning, just as much as their students, and at an age when learning is no longer an easy task.

The Johns Hopkins plan remedies both evils. That school was fortunate to be able to appoint as heads of the three chief departments of clinical medicine, men who always were close students of their branches of medicine, and who are willing to devote all their time to the teaching and the study of their subjects. As to the question, whether it is best that such teachers should have no private practise at all, opinions may differ, especially when this should be considered as a part of a general plan applicable to all medical colleges. As far as I know such a requirement

does not exist anywhere, even in Europe. But, as far as I know, the Johns Hopkins Medical School does not offer its new procedure as a general plan to be used in all other colleges. The Hopkins school follows lines of its own, and with great success. When that school was opened, about twenty-one years ago, the entrance requirements were made very high, indeed higher than at any place in the world, and at a time when most of the colleges in this country had very low requirements. The wisdom of that venture is to-day self-evident. Johns Hopkins Medical School is sending out a high type of medical men into teaching departments, into research institutes and into general practise. The part of the plan which does not permit the professor of clinical subjects to practise for private gain does not deserve to be designated as "grotesque," as has been done in the report of the Council on Medical Education. It probably originated in the desire to put the teachers of clinical subjects on a university basis, and thus maintain a university atmosphere in the medical school, an atmosphere which is essential to the mode of life of the scientific men of that school, and which is readily disturbed by the mode of life of a head of a department "who in a very limited amount of time devoted to practise could obtain for his service much more than the amount of such a salary."

However, it seems to me that this part may be well omitted from a plan which is devised to fit all or most good medical schools. The evils would be satisfactorily mended when study and teaching were the primary occupations of the head of a department. What he does with his spare time should not be our concern. We could not object, if he used it for some hobby; we should be rather glad, if he utilized it for practising medicine.

The Council on Medical Education says in its report that the Johns Hopkins plan "has not been well received by the clinical teachers and finds its supporters almost entirely among the laboratory men." The council has, as stated above, not yet made any definite suggestions; but it is very emphatic on the one point, namely, "whatever plan is adopted must make it possible for the clinical teachers to remain the great authorities in their special field both in the eyes of the profession and of the public." I wish to say here with emphasis that I have a profound admiration for the great work which the council has done in the short time of its existence. The results which it has achieved in the elevation of medical education of the United States are manifold: the general demand for higher entrance requirements; the weeding out of unfit medical schools; reducing in general the number of medical schools and the number of unfit practitioners in the United States; encouraging full-time professors for the purely scientific branches; demanding bedside instruction in clinical subjects and the creation of laboratories and the demand for laboratory work in clinical departments. The personal composition of the council has been usually good—authoritative indeed, as far as the above-mentioned premedical and medical education is concerned. But will the council as well as the committee which it has appointed remain authoritative and unbiased in their judgment also on the subject with which we deal here? We have seen that the two great evils of the present system consist in the facts that for our present heads of clinical departments instruction is only a secondary occupation and that on account of the extensive work which their primary occupation demands they are unable to follow efficiently the continuous progress of medicine. I have no doubt that the ten clinicians which make up the strong committee are "great authorities in their special fields both in the eyes of the profession and the public," that is, they are great practitioners and consultants. But for this very reason they are just the men who are not fit to be heads of departments in medicine. Will the members of this committee and the members of the Council on Education be unbiased enough to recognize the fact that being a celebrated consultant and being an efficient teacher of modern medicine are separate capacities which frequently exclude one another? The frequent repetition in the report of the council of the requirement

that the men to be chosen must be great authorities in the eyes of the public and the profession is, to say the least, disconcerting. To be a great authority in the eyes of the public is surely no evidence even of being an efficient consultant. Any one who is frequently mentioned in newspapers as having been called in consultation to treat this or that rich or noted man, or who has charged enormous fees, etc., stands as a great authority in the public eye and, I am afraid, not infrequently also in the eyes of the profession—in its present state of medical education.

I come now to a more detailed statement of my own suggestions. I shall say at the start that whatever the ideal plan may be, it should not be attained by revolutionary steps; *accelerated evolution gives better and safer results than revolution.* The changes should not be introduced abruptly; they should be gradually developed and adapted to the particular condition of each individual medical college. But these changes should in all cases be in the direction of one and the same ideal plan which could finally serve as a standard for all medical schools. Now as to this plan. I have given above a brief outline of it. But it dealt only with the head of a medical department. I wish now to consider the composition of the entire department. Generally it ought to be made up of the following four groups: (1) A head for whom this position should be his main occupation; (2) two, three or more paid scientific assistants for whom this position should also be their chief occupation; (3) several professors and associate professors, etc., for whom these positions will be secondary occupations, their chief occupation being their private consultation or family practise; some of these may receive moderate salaries; (4) an unlimited number of unpaid volunteer assistants. I should say here that all these positions should be appointments, limited variously to varying periods of years.

The head should give about eight hours a day to this, his main calling, and they should be his fresh hours, say, from 8 A.M. to 4 P.M. After these hours he may do with his time as he pleases. He may accept private consultations at his office or at the bedside and keep the fees. *But he should have no private patients at the hospital in the department of which he is the head.* If this hospital has paying patients, all the income from these patients goes to the budget of the hospital. He should not accept consultations for the first eight hours of the day, and he should make it his business to avoid spectacular consultations. He should do his best to be appreciated by the best of his profession, but to do also his best to avoid standing continuously in the public eye. *He should help to make medicine a science and its teaching a serious business, and by his behavior he should assist in the efforts to deprive the practise of medicine of its commercial aspect.* For a head of a department the first two reappointments should be for five years only; a further reappointment, if it takes place, should be until age limit. This will serve as an efficient corrective against misuse of position or mistaken election. The salary of a head of a clinical department should at least equal the highest given at that university.

The election to headship must be based upon evidence that for the past years the appointee has been continuously a close student of modern medicine and showed efficiency in teaching, as well as in research, in the scientific and practical fields of medicine. The work of the department should be conducted with the aid of all three classes or groups, but especially with the aid of the scientific assistants.

These shall be elected from graduates who have given evidence of possessing higher abilities and ambitions, and who had one year service in a good hospital and one year laboratory work in the science of medicine. They shall be appointed for three years with salaries varying from $1,000 to $2,500. During the first period their entire time should belong to the department; when reappointed, however, for a second period, they should be required to give only about eight hours a day to the department and use the balance of their time for the acquisition of some kind of a pri-

vate practise. The senior assistant should serve as adjunct to the head. It should be the duties of these assistants, besides conducting the routine work of the department with all its ramifications, to take up successively, every six months of these three years, special parts of medicine for a special study, so that at the end of the three years they would have acquired an intimate knowledge of the entire field of their department. They should also acquire successfully a fair knowledge and technique of all or most of the sciences allied to medicine. They should follow closely the new steps made in medicine and the allied sciences and test the reliability and practical applicability of new statements. I shall not enter into further particulars of their duties, which in the main should be guided by the head of the department.[4]

When these scientific assistants have served from eight to ten years, they will be in most cases well qualified to investigate and teach modern medicine from a scientific as well as from a practical point of view. That is the new class of physicians, of which I spoke above, which should be created and from which the new heads of clinical departments should be chosen. If a number of high-grade medical schools would accept this part of the plan, in eight or ten years the country would be provided with a group of a higher type of clinicians. They will then work for the further development of this new type and our problem would find a permanent solution.

The third group should consist, as stated before, of professors, associate professors, etc., who should teach practical medicine at the bedside and for whom the teaching part may remain, as it is now, their secondary occupation, their primary occupation being private practise. They should be appointed for periods of five years and receive some remuneration. They should be selected from the consultants and practitioners of the town where they are recognized for their ability and efficiency. They should teach medi-

[4] The problem of research which ought to occupy the clinical departments, and the methods of teaching which they ought to follow are too extensive subjects to discuss them here. I wish, nevertheless, to append here the following brief remarks:

1. Recent writers were emphatic in their statements that diagnosis and therapeutics are the exclusive fields for clinical research. When a clinician begins to study pathological and physiological problems it is time for him, they say, to leave clinical medicine and become a pathologist or a physiologist. This is a fundamental error and an unfortunate misconception of the scope of medicine. Diseases are experiments made by nature which great clinicians ought to try to interpret not merely by pressing them into facts, views or classifications found or put up by others, but also by original, broad views and illuminating conceptions of their own, if they are the brainy scientifically well-trained men which they ought to be. Medicine had to wait long for the appearance of clinicians like Graves, Addison, Gull and Kocher and Minkowsky to bring to light new forms of diseases and to shed light upon the normal function of apparently obscure organs. If clinical medicine will attract real brainy men who had a thorough training in the methods of investigations in the adjoining exact sciences and who would choose medicine as their field of investigation, a flood of light would be thrown in rapid order upon the nature and the course of the functional processes in disease and in health. 2. Even in this, more scientific part of the department, the practical education of the students must be foremost in the mind of the teacher. They should be taught, here, indeed, the medicine as it is known all over the world today. But newer things ought to be tested at the department for their reliableness and usefulness and ought to be made handy and practical, before they are handed over to the students. All students ought to be trained, in the first place, to become efficient practitioners. They will have to see many patients in one day and will have to act quickly and efficiently. New things appear daily; some are very complicated and some have only a temporary place in practical medicine. By loading the minds of the average student (and practitioner) indiscriminately with the "newest things" in medicine, we create there a haze which interferes with the promptness of the practical activity. Departments of medicine which will seriously and in an unpreoccupied manner test all new things before putting their stamp upon it, will act as very meritorious clearing houses for the practise of medicine.

cine from the point of view of their rich, personal experience.

The fourth group, the volunteer assistants, should consist of younger men of ability of the practitioners' class. Officially they should work with and under the last-named group of teachers, but suitable men should be admitted for special purposes to the laboratories of the scientific staff. Under certain proper circumstances one or the other man of this group may be appointed to the staff of scientific assistants. The appointment of volunteer assistants should be for two years, and if after one reappointment they are not found deserving of advancement to the regular staff, they should not be reappointed.

As far as teaching is concerned, all parts should work as a unit, regulated chiefly by the head of the department.

The necessity for reappointment will serve, as stated above, as a valuable controlling factor; the power of appointment and reappointment should therefore be exercised with great care. I would suggest the following distribution of power. Heads of departments and full professors should be appointed, or reappointed, by the university; all other members of the staff should be appointed or advanced by the members of the medical faculty. In appointing and reappointing scientific assistants the head of the department should have at least three votes.

A head of a department who does not wish a reappointment, or is not reappointed, after ten years' service, shall have the right to be transferred to the practical department with the title professor—unless there are potent reasons against such a transfer. This, in conjunction with the privilege of having some private consultations at his own time during his occupancy of the headship, will compensate the head of a clinical department for the failure to obtain an appointment for life.

As to the relations of hospitals to the teaching department I can be briefer. There must be one hospital which is devoted exclusively to the teaching and study of clinical branches of medicine. While it may have laymen as trustees and a medical superintendent with the necessary clerical staff for the conduction of the business of the hospital, the actual management of its inside affairs should be exclusively in the hands of the medical faculty, and the inside affairs of each department should be exclusively or essentially in the hands of its head. This hospital should not have many private rooms for well-to-do patients, and, as stated above, they should not be used for private patients of the head of the department or any other member of the faculty. The income derived from the treatment of well-to-do patients in private rooms should go to the funds of the hospital.

There ought to be at least one other hospital at the disposal of the medical school which may have many private rooms. Here the practical staff of the school will teach at the bedside—in addition to their right to send patients to and teach at the school hospital—and here the consultants and practitioners belonging to the school may treat their private patients in the private rooms.

The students of medicine will have then a chance of learning predominantly modern scientific medicine at the one, and predominantly practical medicine with a mixture of art at the other, hospital. He will then be able to make his selection as to his future career, according to his natural inclinations and preceding impressions, whether it be scientific medicine with its elevating atmosphere, or active practise and all that goes with it.

S. J. Meltzer

Rockefeller Institute for Medical Research

## *RESEARCH AND TEACHING IN THE UNIVERSITY*[1]

1. No verifiable evidence has been published which proves how research affects the quality of university and college instruction.

2. I believe that research work usually improves the teaching of the instructor, both in the subject in which the research is conducted

[1] Answers to twenty-one questions addressed to the writer by Messrs. William H. Allen and E. C. Branson, directors of a survey appointed to report on the work of the University of Wisconsin.

and in other subjects. It, however, depends on the man and the circumstances. Some men of character and ability may use their time most profitably in teaching. On the other hand, it may be the duty of some instructors to devote themselves mainly to research, even though they are therefore compelled to neglect somewhat their students. It is the duty of the university professor or instructor in equal measure to advance knowledge, to teach students and to serve the public. He should undertake what he can accomplish to best advantage.

3. Research affects methods of instruction directly in so far as it leads the instructor to think more independently and to gain command of his subject instead of depending on text-books. The principal arguments, however, for encouraging instructors to do research work are: (1) It is the business of the university to advance knowledge and to train men to advance knowledge; (2) Better men can be obtained if they are permitted to do research work, and (3) This gives an objective criterion of their ability.

4. Whether the teacher benefits most by research which he conducts alone, by research in which he is assisted by students, or by supervising the research of students, would depend on the circumstances of the case. An efficient professor would probably use the three methods. Perhaps on the whole the 'prentice method is the most desirable and the most economical in the production of scientific results.

5. The extent to which a student is helped by assisting the instructor depends on the kind of work he is set to do, the amount of freedom he is given and his understanding of the problem on which he is working.

6. The student who engages in research work uses the correct method of learning by mastering one subject and relating other knowledge to it; he gains in interest, in independence and in power of initiative, and he learns how to do research work.

7. The result of the instructor's research would usually be to increase his enthusiasm in teaching, which would doubtless apply more directly to the subject which he is investigating and to advanced classes, but it would tend to hold to a certain extent in all cases.

8. Both scholarship and research are important, but I regard the latter as the more important.

9. It is desirable for the student to choose some special subject for work and to connect his other interests with that subject.

10. It follows from this that in preparation for the master's degree or the doctor's degree it is best to require complete mastery of some subject, other knowledge being related to this, rather than to study the whole field of science as it might be represented in a text-book. I regard the preparation of a dissertation as usually desirable.

11. There is, in my opinion, no fundamental difference between adding to knowledge and applying knowledge in new ways. The distinction is between discovering or applying new methods and applying old methods in the old way. The professional school should be on the basis of the university, not of a trade school.

12. I regard knowledge as of value only in so far as it is useful. It may, however, be useful as religion or art is useful. All knowledge is likely to be of use, and the investigator is justified in carrying on investigations the usefulness of which can not be foreseen. I myself prefer investigations the immediate or remote usefulness of which is evident, though an element of danger enters when the utility may be a financial gain to the investigator. It would be desirable to pay the professor an adequate salary and let any money he earned by the application of science go to his department.

13. An instructor in chemistry is usually more usefully employed, even as regards his teaching ability, in conducting chemical investigations than in research as to how to teach chemistry. However, one of the advantages of research is that it leads the instructor to consider and adopt improved methods of teaching.

14. Scientific research is a different problem from helping students. As I understand it,

the object of the questions is to inquire whether the instructor is likely to help students more if he carries on research than if he does not, and my reply is in the affirmative, with the qualification that this is not based on definite knowledge and that much depends on conditions. There is probably a high correlation between ability to carry on research and ability to teach, and the productive scholar or scientific man is more likely to have a beneficial influence on the student than a professor who does nothing but teach and attend athletic events.

15. The stimulating effect of research is doubtless to a large extent due to professional recognition, and in return professional recognition stimulates research. The university should consequently promote the means of publication by professors and instructors, pay their expenses to attend scientific meetings, invite scholars and scientific men from other institutions to lecture and give courses, arrange for the exchange of instructors and the like.

16. It is more desirable for instructors in the department of education to study methods of instruction than for instructors in other departments to do so.

17. The more advanced a student is, the more desirable is it that his instructors should be engaged in research work. This would also be desirable even in elementary schools, but it is not at present feasible to obtain teachers competent to do research work or to pay them. Perhaps if salaries were more adequate all the way from the elementary school to the university, it might be possible to obtain men competent to do research work, to the great benefit of the students and of the world.

18. Under existing conditions the college or university which fails to provide for research work by its instructors is likely to have mediocre teaching. The better men tend to go to institutions where they will be encouraged to do research work and those who stay are apt to adopt the attitude of the schoolmaster rather than that of the professor. The university or college which does not regard the advancement of knowledge and public service as part of its functions has small claim to public support or private gifts, and is likely to deteriorate in all directions.

19. The amount of productive scholarship and research work conducted in America has increased many fold since the introduction of graduate work in the universities in the seventies, and at present three fourths of our productive scientific men are supported by our universities and colleges. The majority of our leading scientific men are connected with a few universities doing graduate work.

20. It is obvious that if the instructor devotes all his time to teaching, he can not do research work. The science in which America was most productive, prior to the introduction of the modern university, was astronomy, in which subject a large amount of undergraduate teaching was not required. Those men doing the most valuable work do not devote the larger part of their time to undergraduate or class teaching. A professor can teach by example as well as by lecturing.

21. I doubt whether most administrative work by instructors has a stimulating and broadening effect on their teaching. One of the chief dangers to the American university is that honor, influence and salary are given to administrative officers instead of to the productive scholars and men of science who are the university.

J. McKeen Cattell

## SECTION OF ZOOLOGY OF THE AMERICAN ASSOCIATION

Section F—Zoology—of the American Association for the Advancement of Science will hold its annual meeting at Philadelphia, December 29, 30 and 31, in conjunction with the American Society of Zoologists and the American Society of Naturalists. All sessions will be held in the lecture room of the zoological department of the University of Pennsylvania. A joint symposium has been arranged for the afternoon of Thursday, December 31, with the following program:

E. G. Conklin—The cultural value of zoology.

C. B. Davenport—The value of scientific genealogy.

G. H. Parker—The coming problems of eugenics.
Stuart Paton—Modern aspects of the study of the mind.
H. F. Osborn—The museum in the public service.

The address of Dr. Mayer, the retiring Vice-president of Section F, will be given at the close of the Naturalists' banquet, Thursday evening, December 31. Dr. Mayer will speak with lantern illustrations upon the work of the Tortugas Laboratory.

As under the rules of the American Association the officers of national societies take charge of the program of joint meetings, the program of the Philadelphia meeting will be in the hands of the officers of the American Society of Zoologists. All titles and abstracts of papers therefore should be sent to Professor Caswell Graves, Johns Hopkins University, before the first of December. But members of Section F, American Association for the Advancement of Science, who are not members of the American Society of Zoologists, may send them to H. V. Neal, Tufts College, Mass.

## SCIENTIFIC NOTES AND NEWS

THE National Academy of Sciences will hold its autumn meeting at the University of Chicago on December 7, 8 and 9.

THE Association of German Scientific Men and Physicians will hold no meeting this year.

THE past and present members of the scientific staff of the Rockefeller Institute for Medical Research gave a dinner at Delmonico's to Dr. Simon Flexner on October 16, in celebration of the tenth anniversary of the opening of the laboratories of the institute under his direction. The members of the board of scientific directors and of the board of trustees were present but the dinner was not public. Dr. S. J. Meltzer presided; a short address, engrossed on parchment and signed by the members of the staff, was read and presented to Dr. Flexner. The following spoke: Dr. W. H. Welch, Mr. F. T. Gates, Mr. John D. Rockefeller, Jr., Dr. Peyton Rous, Dr. Hideyo Noguchi, Dr. F. R. Fraser, Dr. Jacques Loeb, Dr. Rufus Cole and Dr. Flexner.

THE *Observatory* states that among the visitors to the Royal Observatory, Greenwich, during September, were Professor and Mrs. W. W. Campbell, Professor H. D. Curtis and party of the Lick Observatory, and Professor C. D. Perrine and Mr. Mulvey, of the Cordoba Observatory. Both parties were returning from eclipse expeditions in Russia, neither of which, unfortunately, met with success, owing to cloudy skies. The Lick Observatory party was stationed near Kiev, practically on the central line, while the Cordoba observers were near Theodosia with Professor and Mrs. Newall.

DR. ALBRECHT PENCK, professor of geography at Berlin, and Dr. Otto Maas, professor of zoology at Munich, who attended as guests the meeting of the British Association for the Advancement of Science in Australia, are, according to a press despatch, detained in England. Dr. Otto Lutz, professor of biology in the Institute Nacional de Panama, the author of an article in the last number of SCIENCE, is held there as a prisoner of war.

LEAVE of absence has been granted by the trustees of Princeton University to Professor Pierre Boutroux, of the department of mathematics, who is in the French service, and to Professor Joseph H. W. Wedderburn, of the same department, who has returned to England to enlist in the British army.

DR. ROBERT W. GEDDES, professor of anatomy in McGill University, has been called by the British war office to take command in one of the home regiments. Dr. Geddes was a reservist of the British army, having served with distinction in the South African War. He became professor of anatomy in McGill in 1912.

THE New York Section of the American Chemical Society has appointed a committee to examine into the feasibility of expanding the manufacture of chemicals and dyestuffs in the United States. This committee is composed of H. A. Metz, I. F. Stone, J. B. F. Herreshoff, David Jayne, J. M. Matthews, Allen Rogers and B. C. Hesse, chairman.

A cooperative agreement has been entered into by the University of Illinois and the U. S. Department of Agriculture, whereby all of the demonstration work done by the department will be in cooperation with the University of Illinois and under the management of the same organization that administers the Lever bill. Pursuant to this plan of cooperation, Mr. W. F. Handschin, now of the animal husbandry department of the university, has been appointed state leader in charge of the county advisory work, both under the Lever bill and the cooperative relations with the department.

Dr. L. A. Bauer gave an illustrated lecture before the Franklin Institute, at Philadelphia, on October 21, his subject being "The Earth, a Great Magnet."

Professor J. M. Aldrich, of the U. S. Bureau of Entomology, who was for many years a professor of geology in the University of Idaho, gave a lecture at the University of Illinois on October 14 on "Western Salt Lakes and Their Inhabitants."

Sir J. J. Thomson delivered his presidential address to the Physical Society of London on October 23, the subject being "Ionization."

In connection with the London County Council's plan of indicating the houses in London which have been the residences of distinguished individuals, a tablet has, as we learn from *Nature,* recently been erected commemorating the residence of Benjamin Franklin, at 36 Craven Street.

The scientific library which Professor Newton H. Winchell gave to the University of Minnesota is estimated to be worth six thousand dollars. It is a valuable collection of books and serial publications in geology, archeology and related subjects, collected by Professor Winchell during his long life engaged in scientific work.

A portrait of the late Dr. Reginald Heber Fitz, by Mr. I. M. Gaugengigl, of Boston, has been presented to the Harvard Medical School by more than one hundred former associates and pupils. At the presentation made at a full meeting of the faculty of the school, President Lowell presided and the gift was formally made to the university by Dr. Harold C. Ernst. Dr. Fitz was professor in the Harvard Medical School from 1873 to 1908.

Bernard Richardson Green, civil engineer, superintendent of the Congressional Library building and grounds, died on October 22, aged seventy-one years. Mr. Green was born at Malden, Mass. He was graduated from the Lawrence Scientific School, of Harvard University, in 1864. For fourteen years subsequently he was engaged with officers of the United States Corps of Engineers in constructing permanent seacoast fortifications in Maine, New Hampshire and Massachusetts. Since then he had been in charge of the erection of public buildings in Washington, including the State, War and Navy Buildings, the Washington Monument, Army Medical Museum and Library, United States Soldiers' Home, the Library of Congress, the Washington Public Library and the National Museum Building.

Dr. Hans Halle, assistant in plant physiology in the University of Munich, has died as the result of wounds received in the war.

The death is announced of Dr. Maximilian Reinganum, professor of physical chemistry, in Freiburg i. Br.

On account of the situation in Europe and America created by the war, the executive committee for the Second Eugenics Congress has decided that it will be impossible to hold the proposed congress in New York City in September, 1915. The existing organization will be maintained, pending the reestablishment of settled conditions, when the committee will determine upon a new date. The executive committee hopes for the continued interest of those who have consented to serve as members of the several committees and as officers of the congress.

Since the European war broke out Holland has increased its appropriation for the Panama-Pacific International Expedition from $100,000 to $400,000; Argentine from $1,300,000 to $1,700,000. France, which appropriated $400,000 for her participation, has sent word that there is no change in her plans. Japan is pre-

paring a comprehensive national representation and appropriated $600,000. Thirty-nine foreign nations will participate in the exposition.

In the *Observatory* the monthly notes entitled "From an Oxford Note-book" begin as follows: "There is but time for a hurried note or two to catch the mail, for the upheaval in Europe has transmitted waves of minor disturbance to the Antipodes, which have eliminated the small intervals of leisure originally allowed us by Australian hospitality. The news of the war reached us by wireless telegraphy a day or two before our landing, with an effect on a company containing representatives of many nations which can well be imagined. Sir Oliver Lodge, the retiring president, at once struck a note which has been resonant ever since; rising from his chair at dinner he remarked that science knew no politics, he called attention to the presence of various distinguished foreign guests among us, and took the opportunity of drinking their very good health. The brief simple words were received with a burst of applause. When we landed and were most hospitably entertained at Perth, the same spirit was abroad; at the conferring of honorary degrees at Adelaide (and afterwards here at Melbourne), the German visitors were specially and heartily applauded—and whenever Germany was mentioned, it was to speak of all that it had done for science. Finally, it was made clear from the first that the main desire of the Australian people was to carry through with as little disturbance as possible the splendid program they had arranged for us. Balls were, of course, turned into receptions, and the National Anthem was a notable feature of all the earlier gatherings; but the scientific part of the program has been up to the present fully carried out."

The magnetic survey vessel, the *Carnegie*, arrived at Brooklyn on October 21, having completed a cruise of about 10,000 miles this summer in the North Atlantic Ocean. *En route* from Hammerfest, Norway, to Rejkiavik, Iceland, she reached the latitude of 79° 52′ north, off the northwest coast of Spitzbergen. Mr. J. P. Ault, of the Department of Terrestrial Magnetism, was in command of the vessel; he was assisted in the scientific work by Dr. H. Y. W. Edmonds, and by Messrs. H. F. Johnston, I. Luke and N. Meisenhelter.

A cablegram from Buenos Ayres states that Sir Ernest Shackleton's Antarctic steamer *Endurance* is coaling at Montevideo, Uruguay. She reports that she had a bad voyage. She was delayed to such an extent that the coal became exhausted, and she was forced to burn her spars to make port. Sir Ernest Shackleton and the members of his staff are said to be well. They expected to leave Buenos Ayres for the Antarctic region about October 23, and to be able to arrive in the Weddell Sea about the end of November. Sir Ernest said that if he is compelled to go into winter quarters at some point on the Weddell Sea he believes that he may be unable to communicate with the civilized world before about March, 1916.

The American Genetic Association, Washington, D. C., offers two prizes of $100 each for two photographs, one of the largest tree of a nut-bearing variety in the United States, and one of the largest broad-leaf tree which does not bear edible seeds. In the first class, for example, are included trees such as chestnut, oak, walnut, butternut and pecan; and in the second, trees such as elm, birch, maple, cottonwood and tulip poplar. No photographs of cone-bearing trees are wanted, since it is definitely known that the California big trees have no rivals among conifers. At a later time the association may take up the same question as between the various kinds of conifers, such as pines, spruces, firs, cedars and cypresses. The announced purpose of the Genetic Association is to bring about the dissemination of seed or stock of the best specimens, when found, to demonstrate, if possible, the value of heredity in tree growing. The contest ends on July 1, 1915.

The non-resident lecturers in the graduate course in highway engineering at Columbia University appointed for the 1914–1915 session are as follows: John A. Bensel, New York state engineer; Edward D. Boyer, cement and con-

crete expert, The Atlas Portland Cement Company; Sumner R. Church, manager, research department, Barrett Manufacturing Company; William H. Connell, chief, bureau of highways and street cleaning, Philadelphia; W. W. Crosby, chief engineer, Maryland Geological and Economic Survey; Charles Henry Davis, president, National Highways Association; Arthur W. Dean, chief engineer, Massachusetts Highway Commission; John H. Delaney, commissioner, New York State Department of Efficiency and Economy; A. W. Dow, chemical and consulting paving engineer; H. W. Durham, chief engineer of highways, Borough of Manhattan, New York; C. N. Forrest, chief chemist, Barber Asphalt Paving Company; Walter H. Fulweiler, chief chemist, United Gas Improvement Company; D. L. Hough, president, The United Engineering and Contracting Company; William A. Howell, engineer of streets and highways, Newark; Arthur N. Johnson, highway engineer, Bureau of Municipal Research, New York; Nelson P. Lewis, chief engineer, Board of Estimate and Apportionment, New York; Philip P. Sharples, chief chemist, Barrett Manufacturing Company; Francis P. Smith, chemical and consulting paving engineer; Albert Sommer, consulting chemist; George W. Tillson, consulting engineer to the president of the Borough of Brooklyn, New York; George Warren, president, Warren Brothers Company.

Greenhouses for work in plant pathology and plant physiology are now in process of erection and will be ready for use within a few days at the University of Illinois. These comprise 12 greenhouse rooms to be equally divided between the two subjects. Greenhouses are usually provided with ample heating arrangements but these new houses of the university will also have in connection an ample refrigerating plant so as to enable such sections of the house as may demand it to be cooled to the desired point. There is provision, such that any desired area may be isolated, "quarantined" from other sections and also for regulating the humidity and other factors of environment in such way as may be necessary in studying disease resistance, immunity, etc.

Secretary Lane has issued an order designating as nonirrigable under the 320-acre homestead law more than a million acres of land in the state of Oregon. The effect of this order, which becomes effective November 10, is to make such of these lands as are vacant and subject to entry available to be taken up as enlarged homesteads of 320 acres each. Those having within the designated area entries of 160 acres upon which final proof has not been made may apply to enlarge their homesteads to 320 acres by taking up an additional 160 acres of any of the designated land which is surveyed, vacant, nontimbered, etc., and which adjoins their present entries.

The Panama-Pacific International Exposition is provided with its own railway system, which runs through all the exhibit palaces and throughout the exposition grounds, connecting with the freight ferry slip near the Palace of Machinery. Cars may be switched into the exhibit palaces and exhibits unloaded in the space in the palaces which they are to occupy. Under the classification of exhibits each group and class of exhibits at San Francisco is assigned a certain area in the exhibit palaces, an arrangement which simplifies to an extraordinary extent the actual placing of exhibits. When an exhibitor makes application for exhibit space his application automatically falls into one of the eleven different exhibit departments and automatically will be placed in one of the eleven exhibit palaces. Consolidation agencies are established in the east and exhibits routed direct to the exposition grounds. Whenever possible exhibits are made up in carload lots. More than seventy thousand tons of exhibits will be shown at San Francisco, involving a freight charge of more than $3,000,000. Exhibits brought from different portions of the United States will be returned without charge to the exhibitor, provided they have not changed ownership. When a car load of freight reaches Oakland it is barged across San Francisco bay to the exposition freight ferry slip, or, if shipped via San Francisco Peninsula, it will come by the

Belt Line directly into the exposition grounds. When foreign exhibits reach San Francisco bay by steamer they are barged to the exposition freight ferry slip.

IN Virginia there are 700 school and civic leagues organized in the country school districts by the Cooperative Education Association, which is a citizens' organization working in conjunction with the State Department of Education. A school and civic league is "a social club, school betterment association and chamber of commerce set down in a country neighborhood and holding its meetings in the schoolhouse. Officers are elected, meetings are held monthly or fortnightly, and the teacher is a leading spirit in all activities." It is a means of community education for practical citizenship adapted to rural conditions and needs. In addition to musicals, spelling bees, and other social activities, discussion and debate of public questions, primarily of local interest, occupy the meetings. The Cooperative Education Association sends to each league programs on such questions as health, good roads and better farming. A home reading course has been established, based on a text-book on some rural subject and supplemented by bulletins from the several state departments and from the College of Agriculture. Upon the completion of the course members are awarded certificates. The civic training afforded by the leagues comes largely, however, through activity in behalf of better community conditions. One league last year raised $2,500 for the improvement of the roads leading to the school, and this year the good roads meeting held in a one-room school started a movement for an automobile road over 100 miles in length. The improvement of the school itself is, of course, one of the chief interests of the leagues. In 1912–13 they collectively raised $65,000 which was expended for libraries, pictures, pianos, window shades and other improvements. In a sparsely settled section of Charles City County, which until a year ago had no school facilities, a league was formed, an old farm building was rented and furnished with a few chairs and a table, and the school trustees were requested to supply a teacher. Interest increased and finally a model one-room school building was erected, partly by public funds and partly by money raised by the league. Many high schools in Virginia have been built in just this way.

## *UNIVERSITY AND EDUCATIONAL NEWS*

THE corporation of Yale University has approved plans for the new pathological laboratory of the Medical School, in connection with the New Haven Hospital. This building is to be called the Anthony N. Brady Memorial, and is a gift of members of the Brady family.

THE Baltimore Association for the Promotion of the University Education of Women again offers a fellowship of $600 for the year 1915–16 available for study at an American or European university. Applications must be in the hands of Dr. Mary Sherwood, chairman of the committee on award, before January 1, 1915.

THE trustees of Princeton University have increased the tuition for regular students from $160 to $175 a year, beginning September, 1915. The remission of tuition which is granted to needy students has been increased from $100 to $115.

BEGINNING this autumn only the degree of bachelor of arts will be awarded to students of the college of the University of Pennsylvania, the degree of bachelor of science in the arts course having been discontinued.

PROFESSOR A. N. WINCHELL, of the University of Wisconsin, is trying the experiment of teaching the microscopic study of minerals and rocks by correspondence, under the auspices of the Extension Division of the University. Each student must be equipped with his own petrographic microscope and thin sections.

THE Aix-en-Provence University has invited the Belgian universities to send their faculties and students to Aix, offering to provide free lodging for the students. The university has asked the minister of education for the privilege of granting degrees to the refugee students.

Dr. T. E. Hodges, president of the University of West Virginia, has resigned to become a candidate for congressman-at-large.

Professor James William Toumey has been elected director of the Yale School of Forestry for five years, in place of Henry S. Graves. Professor Toumey has been acting director during Professor Graves's absence as United States forester.

Professor M. A. Rosanoff, for the past seven years director of the department of chemistry in Clark University, has accepted a professorship of chemical research in the Mellon Institute of Industrial Research and the graduate school of the University of Pittsburgh. Dr. Rosanoff's students have resigned fellowships at Clark and have followed him to Pittsburgh.

Dr. Homer F. Swift has been appointed associate professor of the practise of medicine in the College of Physicians and Surgeons of Columbia University in succession to Dr. Theodore C. Janeway, now of the Johns Hopkins Medical School.

Dr. Alwin M. Pappenheimer has been appointed professor of pathology in the College of Physicians and Surgeons, Columbia University, to succeed Dr. James W. Jobling, who has become professor of pathology in Vanderbilt University.

In the University of California Dr. Walter Lafayette Howard, since 1905 professor of horticulture in the University of Missouri, has been appointed associate professor of pomology. Dr. Jacob Traum, until recently of the staff of the division of pathology of the Bureau of Animal Industry of the United States Department of Agriculture, has been appointed assistant professor of veterinary science, and will devote his time to investigations in regard to tuberculosis in the domestic animals. Roland S. Vaile, until recently collaborator in the United States Bureau of Entomology, has been appointed assistant professor of orchard management. He will be attached to the Graduate School of Tropical Agriculture at Riverside.

At the Massachusetts Institute of Technology in the department of mechanical engineering, E. W. Brewster and Arthur F. Petts have been named assistants, and Henry M. Wylde, Robert T. Gookin and Walter Haynes, assistants in inorganic chemistry, food analysis and electrical engineering, respectively. Dr. Charles A. Kraus has resigned as assistant professor of physico-chemical research.

## DISCUSSION AND CORRESPONDENCE

### EVOLUTION BY SELECTION OF MUTATIONS

Hugo de Vries, in his Brussels address delivered last January and printed in Science of July 17, with an annotation by the author replying to a criticism of his theory by Edward C. Jeffrey, objects to evolution by selection of fluctuating variation on the ground that this is too slow a process for the length of geologic time.

He does this without offering any evidence that evolution by selection of mutations would be any faster process. He admits that "it is hardly probable that these jumps are numerous in a state of nature as it now surrounds us."

Is there any more presumption in favor of a more rapid rate for evolution proceeding by jumps separated by long intervals from each other than by evolution proceeding by constant though imperceptible steps?

Until we are in possession of such quantitative data we are not in a position to affirm how much change may or may not take place in organisms in a given period of time.

Croll, I think it was, offered a word of caution here. It was to the effect that no one was in a position to say offhand what might or might not take place in a million years.

It has always seemed to me that Herbert Spencer pretty effectually answered the "not-time-enough objection" to evolution, even by the slow process of imperceptible change in organisms; by a comparison of ontogeny with phylogeny and the drawing of a conclusion in accordance with the simple "rule of three."

Taking the development of man in his individual history of 40 weeks from germ cell to fully developed human being, as an epitome of the development of the animal kingdom

from protozoan cell to highest vertebrate in the course of geologic ages, he let 40 weeks (reduced to hours) represent geologic time—say 20 or 40 million years. For the third term in the proportion he took the number of hours it was necessary to observe the embryonic development in order to detect an appreciable change, and obtained for an answer as the fourth term a number in years which was much longer, even when the shortest lengths of geologic time were taken, than our historic period.

So that it was clear there was plenty of geologic time for evolution to proceed at a pace so slow that it could not be detected within the historic period and still accomplish its perfect work.

When it comes to attempts to estimate geologic time in years it seems to me that most persons must agree that they are not very satisfactory. This is particularly so with those of the physicists who have assumed as a basis for their calculations an origin for our planet, no longer looked upon with much favor in the light of the facts which support the planetesimal hypothesis. These calculations have also been largely invalidated by discoveries relating to the radio-activity of matter.

Of all geologic time estimates, those based upon rate of denudation, and its correlative—the rate of deposition of stratified rocks, seem least unsatisfactory. When these methods are applied to precambrian time it is admitted they amount to little more than wild guesses.

And yet we know that evolution was well on its way before the beginning of Cambrian time.

Walcott has brought to light in the Canadian Rockies abundant evidence of a rich and by no means lowly organized marine fauna at the very beginning of Cambrian time.

He and others estimate that at least 90 per cent. of the total evolution to the present had taken place before the Cambrian period.

Le Conte, even before he had had the benefit of these discoveries, was impressed with the high type of the Cambrian faunas.

His memorable words in this connection are:

When the curtain goes up on geological history at the beginning of the Cambrian Period we find practically all the subkingdoms of the animal kingdom present and ready to answer to the roll call.

In the light of these facts what vistas of practically unrecorded geologic time filled with evolutionary process are opened up to us!

Bold indeed is he who from a rate of development predicated upon that observed during the brief span of the historic period would assert that geologic time is too short for a gradual evolutionary process.

ARTHUR M. MILLER

STATE UNIVERSITY,
LEXINGTON, KY.

### POTASSIUM CYANIDE AS AN INSECTICIDE

READING the article of Professor Fernando Sanford in the October 9 issue, I would add that I have found potassium cyanide very effectual in killing ants in lawns, and it does its work without killing the grass. A half ounce in 6 to 8 quarts of water applied with a sprinkling pot is enough for a nest 18 or 20 inches across.

W. G. BLISH

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## SCIENTIFIC BOOKS

*Dialogues concerning Two New Sciences.* By GALILEO GALILEI. Translated from the Italian and Latin into English by HENRY CREW and ALFONSO DE SALVIO, of Northwestern University, with an introduction by ANTONIO FAVARO, of the University of Padua. New York, The Macmillan Company. 1914. Pp. xxi + 300. Price $2.00 net.

In these dialogues Galileo presents the results of his investigations in mechanics and physics. His representative, Salviati, speaking either for himself or as the reader and expositor of the manuscript of a certain unnamed academician—of course Galileo once again—is the principal speaker, and the source of most of the valuable original ideas. Sagredo, the more learned of the other two interlocutors, occasionally contributes something of importance. Simplicio, as an interested layman, raises the objections which would occur to such a man, and gives occasion for the introduction of alternative ex-

planations or illustrations. In presenting such new and revolutionary views as these of Galileo the dialogue form is really the best that could have been used. It enables the author to consider the questions he treats from various points of view and to answer objections or confirm and enlarge upon his propositions, and to do this in an interesting way. The literary skill with which Galileo uses the advantages which the dialogue affords him is remarkable.

The discussion of the first and second day is devoted to the subject of the resistance which solid bodies offer to fracture. On the first day the talk is not very systematic. Salviati introduces the subject by calling attention to a fact known to all practical men, though seemingly forgotten by the philosophers, that a large structure built of the relative dimensions of a small model is not of the same relative strength, but is always weaker; and declares his intention of proving the relations which must obtain among the dimensions of such structures in order that they shall be of equal strength; but he soon drifts off into other matters. Not to mention them all, we find in this book a discussion of the *horror vacui,* in which is described the famous experiment which showed that a suction pump will not lift a column of water more than eighteen cubits, and in which Salviati describes an experiment to determine the limits of the *horror vacui;* a most interesting discussion of infinitesimals and of infinites; an experiment to determine the velocity of light; a study of the resistance which the air offers to a body moving through it, with a clear statement about the terminal velocity, and the general relation of this to the weight and surface of the body; experiments to determine the specific gravity of air; the isochronism of the pendulum and the relation between its period and its length; and lastly the relation of the pitch of a musical tone to the frequency of the vibration, demonstrated and illustrated by beautiful observations. The range of Galileo's interests and the acuteness of his thought can not be better appreciated than by a study of this book.

On the second day Salviati, after giving Galileo's famous demonstration of the law of the lever, goes on to a more formal study of the relations of the dimensions of beams to their breaking strength.

The third and fourth day are devoted to the study of the motion of bodies. The discussion is the one that is familiar to every one from its use in text-books of mechanics. On the third day the subject considered is linear motion with constant acceleration on inclined planes. On the fourth day it is the path of projectiles. Both these books contain, besides the fundamental propositions which are well known and are still used, a great number of others of less importance, which nevertheless serve to show Galileo's fertility of invention and geometrical skill.

This outline of their contents will show why it was worth while to translate Galileo's Dialogues into English. The book is a recognized classic in physics. The freshness and beauty of the thought and the importance of the matter are unsurpassed. It is a book which should particularly be examined by students of physical science at a stage in their progress at which the appreciation of the great original work of the present day would be impossible. It will bring such students at once into a range of thought which they can understand and will illuminate the arid wastes of the text-books in mechanics with the light of genius.

The translators have succeeded remarkably well in preserving the lightness and grace of the style without sacrificing accuracy of expression. The language used by Galileo is so unsystematic that it must have been often difficult to give the proper equivalents to his words and phrases. One suspects that the correct rendering of a word had sometimes to be determined by geometry. Without being pedantic about it, the translators have tried to use the modern technical equivalents of Galileo's less accurate words, and have succeeded so well that the book can be read easily by any one who has the slightest knowledge of mechanics. The beginner will probably once in a while agree with Simplicio in his rueful

complaint that the author "keeps on assuming that all of Euclid's theorems are as familiar and available as his first axioms, which is far from true." The occasional brief notes of the translators are helpful in the full understanding of the text.

The Dialogues were published in 1638, when Galileo's life was nearly at an end, but it is shown by Professor Favaro in the scholarly introduction which he contributes to this edition, that most of the discoveries described in them were made many years before, while Galileo was at Padua.

The book is printed in a manner worthy of its contents. The diagrams and illustrations are reproductions of the originals. In publishing this translation the authors have done a service to all English-speaking students of the history of physics.

W. F. MAGIE

*Chemistry and Its Borderland.* By ALFRED W. STEWART, D.Sc., lecturer on organic chemistry in the Queen's University of Belfast, etc. With 11 illustrations and 2 plates. Longmans, Green and Co. 1914. Pp. xii + 314. Price $1.50 net.

The scope of this book is best shown by giving the titles of the fifteen essays of which it consists. They are: The Ramification of Chemistry, The Allies of Chemistry among the Sciences, The Relations between Chemistry and Industry, Immuno-chemistry and some Kindred Problems, Colloids and the Ultramicroscope, The Work of the Spectroscope, Chemistry in Space, The Inert Gases and their Place among the Elements, Radium, Niton, Transmutation, The Nature of the Elements, Chemical Problems of the Present and Future, The Methods of Chemical Research, and The Organization of Chemical Research.

The first three of these essays, as well as the last three, appeal most interestingly to the general non-technical reader. The others, which deal with special developments of chemistry, would hardly be intelligently read by those who have no chemical training, but they do serve well to give the chemist a comprehension of the work that is going on in other branches of his specialty. These particular chapters are, however, somewhat lacking in clarity, especially that on immunochemistry. It is difficult to describe advanced work in any chemical field in easily comprehensible language, and a failure to put the theories of Ehrlich and Metchnikoff successfully into popular language is not to be wondered at. Perhaps it is hardly worth while to try.

The essay on Chemical Problems of the Present and Future presents an interesting discussion of the part to be played by chemistry in energy and food supply. As possible developments along the line of sources of energy are suggested more efficient storage batteries and primary batteries, improved methods of utilizing solar radiations, artificial coal, the use of explosives in gas engines, and the use of radium. In discussing food supply the question of fertilizers is dwelt upon, with comments on the annual loss of $80,000,000 in the nitrogen of sewage carried into the sea. The future use of the seaweeds of the Sargasso Sea is mentioned and a good description is given of the fixation of atmospheric nitrogen in the electric furnace. A second division of the food problem is the discovery of new supplies. These may be materials which have hitherto, as foods, gone to waste, as oleomargarine, or they may be synthetic foods. At present the latter are too expensive to be thought of, but processes for their manufacture on a large scale may some time be discovered. This leads the author to a brief discussion of the possible synthetic production of living tissue.

> We have the means of building up more and more complex protein derivatives, and, sooner or later, we shall probably synthesize substances quite as complex as the natural protoplasmic materials; when this point is reached, unless our knowledge of "vital" reactions has considerably advanced, we shall at best be in the position of a watchmaker who has constructed a watch but has forgotten to make any contrivance for winding it up. At this point, chance might enter into the problem, and the protoplasmic machine we have designed might spontaneously set itself in motion, but more than this we are not entitled to

expect. Experiment is the only possible test, and the date of the crucial trial is still far distant.

This, however, does not prevent the author from indulging in an interesting speculation:

Suppose that this new protoplasm had properties slightly different from those types which we know; its accidental discovery might involve us in very serious consequences. Assume that it had great powers of assimilation and reproduction, and we might find it rather a dangerous neighbor, so that finally the new discovery might end in the rapid extirpation of the long-sought-for product. Even more serious, however, would be the state of things if the synthetic creature resembled our ordinary bacteria, and was capable of lodging in animals, and there liberating new forms of toxins against which we are not immunized. It is just a possibility, but it would certainly be a most awkward end to an experiment.

The further career of this future Frankenstein may be left to the speculations of H. G. Wells.

The essays on chemical research may well be commended to every one interested in the future of those industries which are in any way connected with the applications of chemistry. While written from an English standpoint, they are none the less applicable in America. In both these countries the future held out to the student of chemistry is by no means attractive and the expectation of adequate remuneration for a life work is less than in many other fields. Yet the future of these industries is bound up with chemical research, and that not merely in the field of the direct applications of chemistry, but even more especially in the field of pure science, and here it is that there is the least hope of adequate remuneration. The outlook is nevertheless not without hope, both in Britain and in America. The foundation of the Carnegie Trust for the Universities of Scotland and the Science Research Scholarships of the Royal Commission for the International Exhibition of 1851 are dwelt on at length, as steps in the right direction, and in an appendix is set forth the Outline of a Scheme for the Improvement of Research Conditions, worthy careful perusal, however much one may disagree with some of the suggestions.

The book is well written and comparatively free from errors, though exception might be taken to the accuracy of occasional statements. We object seriously to the use, unfortunately far too frequent here and elsewhere, of "body" where "substance" or "compound" is meant, and we wonder if the word "researcher," for one engaged in research, has come to stay.

Jas. Lewis Howe

Washington and Lee University,
Lexington, Virginia

*Nucleic Acids. Their Chemical Properties and Physiological Conduct.* By Walter Jones, Ph.D. Longmans, Green & Co. 1914. Pp. viii + 118.

Nucleic acids and their components have held, for more than a century, the interest of the chemist, of the biologist, of the physician, of the pharmacologist, and of the physiologist.

The first acquaintance with the derivatives of nucleic acid was made through the discovery of uric acid by Scheele in the year 1776. The name given to the substance betrays the scanty information of the discoverer concerning the chemical structure of the acid, hence of its exact place in the economy of the organism. The constant occurrence in the urine of appreciable quantities of uric acid may have led one to the conclusion that it belonged to the class of final products of metabolism. What was the mother substance of uric acid? The question could not be answered when information concerning the chemistry of the tissue components, or of food stuffs, was lacking.

Nucleic acids were discovered much later by Altman, a cell biologist. He was in search for an explanation of the staining properties of cell nuclei. The problem, as far as Altman was concerned, was solved by the demonstration of the presence in the cell nuclei of a substance with the properties of an acid. The substance was named nucleic acid. Altman little thought of the possible relationship of the new substance to the uric acid of the urine. On the other hand, the chemists and physicians engaged in researches on uric acid

suspected as little a relationship between the two acids. It required years of labor to bring the two independent lines of inquiry to a common ground and to a mutual understanding.

The inquiry into the chemical structure of uric acid led up to the classical work of Fischer on the "purin" derivatives. This work established the relationship of uric acid to xanthin, hypoxanthin, guanin and adenin—basic substances discovered in the extracts of animal tissues. It then became evident that the uric acid of the urine is a product of animal combustion of purin bases.

On the other hand, the inquiry into the structure of nucleic acids led up to the knowledge that these acids contain in their molecule purin bases. Thus, by some display of imagination, the origin of the purin bases of tissue extracts could be explained by a rupture of the complex structure of the nucleic acid molecule. The genesis and the fate of uric acid became obvious. This triumph of knowledge is unquestionably important for its own sake. However, in this place it may be of service as an illustration of the scope of biological chemistry as compared with that of the structural organic chemistry.

The discovery of the arrangement of atoms in a given molecule is the aim of the structural chemist. The physical and chemical properties of a molecule are determined by the arrangement of the component atoms. The work of the chemist is completed when he is successful in arranging hypothetically all the atoms of the molecule in such a manner that the conduct of the molecule appears a natural sequence of this arrangement.

Not so simple is the task of a biological chemist. A tissue component is not only a chemical, but also a biological unit. It is not only a reacting body but also a structural element of cells and tissues. Furthermore, it reacts not only in its state of integrity, but also in its state of dissociation. The dissociation is most generally a complex process, and is controlled by well regulated mechanisms. In a word, the scope of biological chemistry is not only the chemical structure of substance, but the life cycle of the structure, and the relation of this cycle to that of the other tissue elements.

Hence, the biochemical problems are very complex, and for the present it is difficult to point out any tissue component regarding which our knowledge is complete.

The subject of nucleic acid is one of the most successful chapters in the history of biochemical inquiry. Not that information is complete either in regard to the structure or in regard to the conduct of this group of substances. But the information that is lacking is small as compared with that already acquired. And the information acquired concerns equally the biologist, the chemist and the physician.

To sum up all the recent progress in this field of research is a very difficult undertaking. Professor W. Jones in his monograph on "Nucleic Acids" has acquitted himself of the task in a most masterly manner. The work contains a very systematic and keen analysis of all the numerous publications in this field of biochemical research. And yet, the book reflects the personality of the author and his interests as an investigator. Dr. Jones has contributed considerably to the knowledge of the chemical structure of nucleic acids, but his most important contributions relate to the process of their disintegration in the organism. Naturally the chapters on the "conduct" of the nucleic acids carry most inspiration. Hence, the biologist, the physician, and the physiologist will read the book with special interest. However, also the chemist will find a complete and very comprehensive review of all the work dealing with the chemical structure of nucleic acids.

The first part of the monograph deals with nucleins, nucleoproteins, and with "nucleic acids" in general. The second chapter of this part gives a good account of the chemistry of nucleic acids of animal origin, and the concluding chapter reviews the results of the recent work on the nucleic acids of plant origin.

The second part gives a critical résumé of the very extensive literature dealing with the questions of biological formation of nucleic

acids, and of the process of their disintegration. Reading these chapters, one can not help being impressed by the complexity of the mechanism which controls the catabolism of nucleic acids. There have been described in the animal organism at least a dozen agents (enzymes) taking part in the work of the destruction of nucleic acids. Undoubtedly more will be discovered. Each of the known enzymes is capable of inducing only one reaction, of performing only one phase in the general process.

The reading of these chapters is instructive, not only for the information contained in them, but as an illustration of the means employed by the animal organism in order to bring about a very gradual transformation of the complex tissue components into simpler derivatives. How great must be the number of enzymes residing in animal tissues if more than a dozen are required for the catabolism of only one tissue component!

P. A. Levene

## *STANDARDIZATION OF COURSES AND GRADES*

The following regulations were adopted for the guidance of the faculty at a recent meeting of the president's council of the George Washington University:

*To the President's Council:* The Committee on Standardizing Grades appointed last June begs leave to submit suggestions upon the following two problems:

1. How can the amount of work required for each unit of credit be approximately equalized in the various courses?

2. What common standard of grading can the various members of the faculty observe so that they will all grade approximately on the same standard?

In submitting principles and standards for the solution of these problems the committee wishes first of all to be understood that it does not wish to dictate, or even to suggest, how any member of the faculty should do his work. It not only has no intention of curtailing the legitimate rights and freedom of any teacher, but it desires especially to emphasize that these rights and freedom are sacred; that they are an indispensable condition for the best type of university work.

But in schools, colleges and universities the personal side is not the only side to teaching. There is present also a social side which grows out of the fact that a school is in some fundamental aspects a social unit. The various members of the faculty are all working to contribute in piecemeal to the same end. They are all contributing to the rounded education of individuals, and to the extent that social relationships are involved in this process to that extent is it necessary to observe similar standards and principles. When this is not done the equilibrium and the efficient working of the whole is disturbed. Students in considerable number will elect those courses in which they can get the largest number of credits or the highest grades, or both, for the least work, and they will shun those courses in which the opposite is true.

But in observing similar standards and principles in those matters that pertain to the school, as a whole, it would seem that no desirable aspect of the personal freedom of the teacher needs to be violated. A common goal only needs to be recognized, the manner of reaching the goal being left to the individual teacher. We have here an example of the type of liberty within law that obtains elsewhere in society.

### *Equalization of Units*

It appears to be true that the amount of work required of students in different courses carrying equal amounts of credit varies greatly. While in some courses little more than attendance upon lectures and the passing of examinations is required, in others from one to three or even four hours of outside preparation for each lesson is required in addition. To minimize this divergence the committee recommends:

(*a*) That all teachers strive to require about two hours of outside preparation for each lesson.

(*b*) That courses which are now so weighted that they can not be completed with this amount of study be readjusted so that they can ordinarily be completed with two hours of preparation for each lesson.

(*c*) That lecture courses in connection with which it is impossible or undesirable to assign any considerable amount of outside work carry one half as many credits as the number of lectures per week.

### *Distribution of Grades*

Considered from the social standpoint, the college, in common with other schools, performs two interrelated, although distinguishable fundamental functions. It (1) educates and it (2) selects.

The educative function is the one commonly recognized and is in outline well understood. It includes the imparting of ideals, knowledge and skill.

The selective function, on the other hand, has been less commonly recognized, but it has always been present and is socially indispensable. The school not only imparts ideals, knowledge and skill, but it also designates those who have acquired these characteristics, and by the assignment of grades it aims to indicate the degree in which they have acquired them.

The giving of grades to students is only one of a number of means that the school uses in discharging the selective function of education, but it is one of the most important. Like other educational functions it must be done carefully, intelligently and uniformly in order to avoid injustice to the student. The desideratum of uniformity requires not only that each teacher always use approximately the same standard with all of his students, but that all teachers use approximately the same standard with all students. When this is not done, the educational equilibrium of the school is disturbed and injustice is done to the earnest and conscientious student. The less serious the students are the more they tend to gravitate toward the teachers that give the higher grades and the injustice that this tends to work upon the conscientious student when it comes to the awarding of honors and the recommending for positions is obvious. The giving of many high grades, furthermore, gives many students a false and exaggerated notion of their ability. The grade of "A" especially should be reserved for very exceptional ability which in the nature of the case is rare.

The principle underlying a uniform standard of grading is found in the distribution of mental ability as revealed by psychological investigations. These investigations have shown, when sufficiently large numbers of people are considered, that ability in general or in any particular line, is distributed in the form of a bell-shaped curve technically known as the probability curve or the normal surface of frequency. Letting the base line represent the degrees of ability from poorest to best and the vertical lines the numbers of persons possessing each degree of ability, it is clear that there is but a small number of students with excellent ability, a larger number with good ability, a relatively large number with medium or average ability, a smaller number with sub-medium but passing ability, and a small number with distinctly unsatisfactory ability.

There are, of course, no sharp dividing lines between these different groups, and any such lines that are drawn are arbitrary. But when the base line is divided into five equal steps, representing therefore five approximately equal steps of ability, the percentages of students that fall into each group are approximately as follows:

| | | Per Cent. |
|---|---|---|
| Excellent | (A) | 4 |
| Good | (B) | 24 |
| Medium | (C) | 44 |
| Sub-medium | (D) | 24 |
| Failure | (E) | 4 |
| Total | | 100 |

These percentages mean in the present connection that a teacher's grades should in the long run be distributed approximately in the amounts indicated by these percentages. The grade of "A," or excellent, should be assigned to about 4 per cent. of the students; "B," or good, to about 24 per cent.; "C," or medium, to about 44 per cent.; "D," or sub-medium, to about 24 per cent.; and "E," or failure, to about 4 per cent. It is quite likely that the percentage of failures in the lower classes may properly be somewhat higher than that in the upper, with corresponding changes in the other percentages, and failures may perhaps also properly be more frequent in professional schools than in liberal culture schools. Because of its immediate social responsibility, it is the duty of the professional school to apply the principle of selection rigidly.

*It should, however, not be inferred that the grades assigned in any particular class, especially in a small class, must approximate closely to the distribution above given. The expression, "in the long run," should be emphasized. The principle can not be applied mechanically, but it devolves upon each teacher to school himself to recognize excellent ability, good ability, and so on.*

W. C. RUEDIGER,
GEO. N. HENNING,
WM. A. WILBUR,
*Committee*

## SPECIAL ARTICLES

### CORRELATION BETWEEN THE TERTIARY OF THE GREAT BASIN AND THAT OF THE MARGINAL MARINE PROVINCE IN CALIFORNIA

IN December, 1913, a party of students from the University of California working

under the leadership of Dr. Bruce Clark, instructor in paleontology, obtained an interesting collection of remains of land mammals in Tertiary deposits north of Coalinga, on the west side of the Great Valley of California. As the Tertiary section in the Coalinga region is a part of the marginal marine series of Californian formations, and the mammalian remains obtained in these beds represent a land fauna best known in the epicontinental deposits ranging from the Great Basin east to the Great Plains region, this occurrence offers an unusual opportunity for correlation between the marginal marine province and the mammal-bearing deposits of the interior of the continent.

Evidence bearing on the problem of correlation between the Great Basin and the Pacific Coast province is particularly welcome at this time, since there has been reason to believe that the geologic scales used in the two regions have not coincided in the limits of the periods.

The mammalian remains obtained in the North Coalinga region were found at not less than four horizons ranging from beds generally considered to be Lower Miocene or Upper Oligocene, to a horizon of Pleistocene or Pliocene stage. The occurrence of the faunal zones in the sequence of deposits in the North Coalinga region is shown in the table.

The lowest horizon is characterized by abundance of horse teeth representing the genus *Merychippus*, and may be known as the Merychippus zone. At the second horizon from the base comparatively few remains are known. The presence of teeth of *Neohipparion* suggests the tentative designation of this portion of the section as the Neohipparion zone. The third of the principal horizons is characterized by the presence of a new species of horse designated as *Protohippus coalingensis* and may be known as the Protohippus coalingensis zone. The latest fauna is distinguished by the presence of a large specialized horse, probably representing the genus *Equus*, and by remains of a form near *Cervus*. This may be known as the Equus-Cervus fauna.

*Occurrence of Mammal Zones in Tertiary Beds of the North Coalinga Region of California*

| Time Divisions | | Local Formations | Mammal Zones |
|---|---|---|---|
| Pleistocene | | Terrace deposits | ? Equus-Cervus fauna in part |
| Pliocene | | Tulare | |
| | | Etchegoin | Protohippus coalingensis |
| | | Jacalitos | Neohipparion |
| Miocene | Upper | "Santa Margarita" | |
| | Middle | "Temblor" | Merychippus |
| | Lower | | |

The fauna of the Merychippus zone occurring in the "Temblor" beds commonly recognized as Lower Miocene, includes the following types.

*Merychippus*, n. sp.
*Tetrabelodon* ?, sp.
*Procamelus* ?, sp.
*Prosthennops* ?, sp.
*Desmostylus*, near *hesperus* Marsh.
*Isurus*, sp.

The horses of the Merychippus zone correspond very closely in most respects to *Merychippus isonesus* of the Mascall Middle Miocene of the eastern Oregon region. The stage of evolution of the teeth of this form is not reached by any species of the Lower Miocene in America. The proboscidean, *Tetrabelodon?*, has no certainly known relatives in America earlier than the Middle Miocene of our accepted scale. The camel resembles a late Miocene type. It seems impossible to refer this fauna to a stage older than that of the Mascall Miocene of the mammalian sequence of the Great Basin province.

From the occurrence of the Merychippus

fauna in the "Temblor" beds of the North Coalinga region, it seems clear that these marine beds, commonly referred to Lower Miocene or late Oligocene, are not older than mammal-bearing beds of the interior of the continent referred to Middle Miocene.

The "Temblor" beds of southern California represent a phase of the Monterey series of California, which is one of the best known and most widely spread of the divisions of the Tertiary. There seems good reason to believe that the Monterey series of California is approximately to be correlated with the Mascall Middle Miocene of the Great Basin.

A broad consideration of the lack of adjustment between the time scale of the Pacific Coast province and that of the Great Basin suggests that correlations of marine faunas of the Pacific Coast region, particularly those based on the percentage method, have tended to locate the time divisions relatively too far from the present or Recent. In late years, the refinement of specific characterization has proceeded very rapidly. Splitting the species has resulted in giving us a larger number of forms each of which has a relatively restricted geographic and geologic range. The percentage method, as proposed by Lyell, when used with modern species naturally results in pushing time divisions farther apart.

The lack of adjustment in the time scale also suggests the desirability of testing the relation of Middle Miocene mammal-bearing beds of North America to the formations of Lower Miocene age in the European scale.

The fauna of the second mammal zone of the Coalinga region comes from beds referred for the present to the Jacalitos formation. It includes a form referred to *Protohippus* by Arnold and Anderson, and a *Neohipparion* species of somewhat advanced stage. The *Neohipparion* material from this zone is insufficient for thoroughly satisfactory comparison. It seems in part to be related to a *Neohipparion* from the Rattlesnake Pliocene of the John Day region of eastern Oregon. This species does not appear to be very closely related to the well-known *Hipparion* species in the Ricardo fauna from the Mohave Desert.

The fauna of the third or Protohippus coalingensis zone of the Etchegoin formation in the Coalinga region has as its most characteristic form a new species, *Protohippus coalingensis*,[1] which differs from all the described species found west of the Wasatch Range. It is most nearly related to a species represented in the Ricardo fauna of the Mohave Desert. It does not, however, seem to be identical with the Ricardo form. The stage of this fauna, in very general terms, seems to be Pliocene. Both the Etchegoin of this zone and the Jacalitos below it were referred by Arnold and Anderson[2] to the Upper Miocene.

The fourth fauna of the North Coalinga region includes a number of species of relatively modern aspect. These include forms referable to *Equus* and to *Cervus* or *Odocoileus*. This assemblage may be known for the present as the Equus-Cervus fauna. Its stratigraphic position is not entirely clear. The fauna is in part much like that of the Pleistocene.

JOHN C. MERRIAM

## THE CRENATION AND FLAGELLATION OF HUMAN ERYTHROCYTES

### I. *Crenation*

THE method of preparing the blood on which the following observations on crenation were made is very simple. A drop of blood obtained by pricking the finger is immediately sucked up into a pipette which contains one to two cubic centimeters of sterile Ringer's solution or 0.85 per cent. sterile sodium chloride or human blood serum. The suspension is then mixed on a sterile glass slide until a homogeneous suspension is obtained. A drop of the suspension is then transferred by means of a pipette to an absolutely clean large coverslip and the drop allowed to spread out into a thin

1 *Protohippus coalingensis*, n. sp. Type specimen, No. 21,341, Univ. Cal. Col. Vert. Palæ. Distinguished by large size, unusual narrowness of cheek-teeth in transverse diameter, small protocone and narrow, simple fossettes.

2 Arnold, R., and Anderson, R., U. S. Geol. Surv. Bull. No. 398, p. 78, 1910.

film. The preparation is then mounted in a glass moist chamber, open to the air at one end, and examined at ordinary room temperature. A drop of untreated human blood mounted in a moist chamber serves equally well, if the corpuscles be more or less separated, by spreading the blood into a thin film on the cover-slip.

The preparations were studied at room temperature by means of both natural and artificial light. A frosted Mazda light globe of sixty watts was used as the source of illumination, the light being passed through a glass container containing sufficient copper chloride to impart a weak blue color to the solution. The following observations were made with an ordinary Leitz 1:12 oil immersion lens and a No. 4 ocular. Certain finer details of structure were better revealed by a No. 12 compensating ocular.

The microdissection technique used is the same as that employed by Kite[1] and involves the use of the Barbour pipette holder, the Barbour moist chamber, and exceedingly fine (1–2 microns) hard Jena glass needles and pipettes.

When blood is prepared as above described certain of the cells are seen to have undergone more or less pronounced crenation as soon as they can be examined. If now a very fine needle point be brought up under a crenated erythrocyte, then carefully elevated so as to just touch the cell, and then immediately lowered, the corpuscle instantly regains an optically normal appearance and retains it for hours. Crenated cells thus brought back to the normal have never been seen to undergo subsequent crenation if left undisturbed. (It should be noted that in bringing the fine point of the dissecting needle into contact with the cell extreme care must be taken; otherwise, although the cell immediately rounds up and swells, yet within 20 to 30 seconds the hæmoglobin dissolves out and only a so-called "shadow corpuscle" remains.)

If a fine needle be raised into a drop containing normal red blood cells no crenation occurs when the needle pierces the meniscus of the drop. If now the needle point be brought up alongside the cell (not touching the cell but in the same focal plane) the corpuscle immediately crenates. The amount of crenation seems to be dependent somewhat on the proximity of the needle to the cell. As long as the needle remains in place the crenation persists, but as soon as the needle is lowered out of the focal plane of the cell the corpuscle instantly goes back to the normal. This experiment of crenating and uncrenating a cell can be indulged in indefinitely, with always the same results.

Various methods were employed. If, for instance, a fine microdissection needle be brought up alongside a completely crenated cell, and if the needle point be then carefully moved against the cell, pushing in a small arc of the cell substance before it, immediately on lowering the needle away from the cell, the corpuscle rounds up and swells. In all the above-quoted and subsequent experiments cells brought back from the crenated stage remained intact and optically normal. In fact, such cells can not be distinguished from absolutely normal red-blood cells.

Even more striking results on a somewhat larger scale are obtained when, instead of a needle, a very fine pipette is employed. The best results are obtained with a glass pipette whose lumen is not more than one micron in diameter. If such a pipette be raised into a field of crenated erythrocytes the instant the pipette pierces the meniscus of the drop all of the crenated and otherwise distorted cells in the field immediately round up and retain their perfectly normal, regular outline and appearance so long as the pipette is allowed to remain in the drop. If now the pipette be lowered out of the drop, all the cells immediately go back to their irregular, crenated shape. The cells that were originally of a pointed oval shape, etc., for instance, return to their oval form, and the variously crenated cells return to their original stage of crenation.

If, into a drop containing perfectly normal red-blood cells, a very fine pipette is raised and the experimenter exerts a very slight suction

[1] A detailed description of the method will be published shortly.

on the pipette, all the cells within a more or less definite zone about the pipette instantly crenate. If now the experimenter blows into the pipette very slightly (the pipette, of course, still being in the drop) the cells immediately round up and remain perfectly normal. This alternate crenating and uncrenating the cells can be indulged in repeatedly.

Examination of red-blood cells kept for hours in a moist chamber gives evidence that probably there are a number of more or less definite types and stages of crenation. In preparations of crenated erythrocytes a varying number (dependent somewhat upon the age of the preparation) are seen to undergo an internal change (as noted by Kite) which is characterized by the formation of refractile granules and rods, of somewhat definite size, in the cell substance. The exact relation of this phase to crenation has not yet been determined. The deposition of these rods and granules is very possibly a coagulation phenomenon. Cells that have undergone such a change are apparently more stable and less easily brought back to the normal than crenated but optically homogeneous corpuscles. Such cells can be sucked up into a pipette and expelled into the same or different drop without undergoing any apparent alteration in shape or size. Such a cell can, however, be brought back to the normal by raising a needle against the cell body and immediately lowering it. The granules and rods instantly disappear and the cell immediately assumes an apparently permanent normal outline and appearance.

*All of the above experiments can be performed equally well whether the blood cells be mounted in an isotonic, slightly hypotonic or slightly hypertonic solution.* Certain of the experiments, especially, would seem to indicate that the phenomenon is apparently outside the sphere of any possible osmotic process, dependent upon an alteration in a hypothetical semipermeable membrane around the red-blood corpuscle. Rather the experiments would lead one to suspect that the shape a red-blood cell assumes is an expression of surface tension forces. The experiments also serve to emphasize the extreme irritability of protoplasm.

### II. *Flagellation*

In an article[2] to be published shortly in the *Journal of Infectious Diseases,* Kite records a series of dark-field observations on the structural modifications undergone by the blood cells of various vertebrates when mounted in liquid plasma containing Ringer's fluid and hirudin and examined in sealed preparations. He records dark field observations of various types of both motile and non-motile processes which appear on the blood cells of vertebrates.

After studying certain of these structural changes in sealed preparations by means of the dark field and special condensers it seemed of interest to more carefully study red-blood cells mounted in a Barbour moist chamber freely open to the air, and to determine whether these changes could be seen by ordinary transmitted light and without the aid of special condensers. For this purpose the following experiments were undertaken. It should be recorded here that, although one type of process mentioned below is apparently coarser and of a somewhat different nature than any of the processes figured by Kite, yet there is no reason to suppose that this type of process is anything more than possibly another phase in the transformations described by him. As can be determined by reference to Kite's paper, priority of certain of the following observations made under somewhat different conditions belong to him. Control observations with hirudinized preparations have been made with the same results. The method of preparing the microscopic mounts is the same as described above under crenation.

Immediately upon making the preparation a large proportion of the red-blood cells are seen to possess very short non-motile spinous processes which line the entire periphery of the cell. Within forty to fifty minutes after the preparation is made the erythrocytes are seen to possess long processes, some of which exhibit a rapid whip-like motion, others a slow undu-

[2] "Some Structural Modifications of the Blood Cells of Vertebrates," G. L. Kite. Read before the Society for Experimental Biology and Medicine, April 15, 1914.

latory movement, while still others are absolutely motionless. These processes, which can be seen to be thrown out from the cell and possess unquestioned continuity with the cell, apparently originate from small blunt projections which appear on the surface of the cell. These processes appear alike on crenated and uncrenated cells, are comparatively easily seen, and vary in length from two to three microns to as long as 30 microns. Under certain conditions, the details of which have not been worked out, they are capable of extremely rapid retraction. Frequently oval erythrocytes with the two ends drawn out into a long fine whipping process which may have a length of five to six times the diameter of the cell are found. Cells with these beating processes are rapidly whipped across the field. These long fine processes, when they first appear on the red cells, are of a clear, non-granular nature. After whipping for twenty to thirty minutes they have been seen to take on a granular, beaded appearance. The beaded processes continue to beat. If watched, certain of these processes can be seen to break off from the cell, and even after being detached, continue to whip across the field. If these detached processes are further observed they can be seen to eventually break down, the granules floating free in the preparation and exhibiting marked Brownian movements. These granules apparently hold up, and at the end of five or six hours are found in large numbers.

By means of the microdissection technique devised by Kite the fine beating processes on the red blood cells have been dissected off. When a process is dissected off the cell, the broken-off process may remain sticking to the point of the needle. The free end continues to whip for as long as forty minutes after being detached from the cell. If a process be dissected off near the cell the small portion remaining attached to the cell continues to whip.

If a motionless process on an erythrocyte is touched at any point along its extent by a very fine needle the process immediately begins to whip. For instance, an erythrocyte of perfectly regular outline with a long (20–30 micron) process at each pole of the cell was watched for forty-five minutes. During this time the cell did not change in outline, and the cell and its processes remained absolutely motionless. At the end of this time one of the processes was touched near its base. The process immediately commenced to whip, and the motionless process at the other pole of the cell took on a very slow undulatory movement. When this latter undulating process was touched by the needle, it, too, immediately commenced to whip. The two actively whipping processes soon carried the cell out of the field, and the cell was followed in its progress through a number of fields. At the end of thirty minutes the processes were still whipping the cell through the preparation. The long processes are exceedingly flexible and seem to beat in an arhythmic manner. They frequently are seen to whip around the cell to which they are attached, and become glued to the surface of the cell. After several minutes they can be seen to beat free from the cell and continue their active whipping motion. The apparent viscidity of the processes is evidenced by the fact that two or more beating processes of the same or neighboring cell frequently become entangled and stick together. They may become freed naturally, or they can be pulled apart by means of the dissecting needle. At times the middle portion of a long process becomes stuck to the cell while the free terminal portion continues to whip.

If a dissecting needle be brought up along side the middle portion of one of these long beating processes, and this portion then be carefully pushed so as to form an arc, the distal portion of the process continues to beat in a line with the motionless proximal portion. If too much tension is placed on the process it is torn loose. The various types of motile and non-motile processes on the red-blood cells can be found in moist chamber preparations of blood mounted in 0.85 per cent. sodium chloride for many hours after the preparation is made (at least twenty-four hours).

Wade W. Oliver

Marine Biological Laboratory,
Woods Hole